THE MINERAL INDUSTRY

THE MINERAL INDUSTRY

ITS

STATISTICS, TECHNOLOGY AND TRADE

DURING

1915

FOUNDED BY RICHARD P. ROTHWELL

EDITED BY

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Gold and Silver in Brazil.
Gold and Silver in Peru,
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THE STATE GEOLOGICAL SURVEYS

Of the 46 States of the Union, 35 have organized geological surveys, these comprising nearly all of the States in which the mining industry is important. The organization of a geological survey in Massachusetts is under consideration. Certain States which have no geological survey have officials who give attention to the mining industry. Thus, California has a State mineralogist, while Idaho has a State mine inspector who collects statistics of mineral production. The States having organized geological surveys, together with the names and addresses of the respective State geologists, as of Jan. 1, 1916, are given in the following list:

STATE GEOLOGISTS.

State.	Name and Address.	State.	Name and Address.
Alabama......	Eugene A. Smith, University.	New Mexico..	Chas. T. Kirk, Albuquerque.
Arkansas......	N. F. Drake, Fayetteville.	New York....	John M. Clarke, Albany.
Connecticut...	Wm. N. Rice, Hartford.	N. Carolina...	Joseph Hyde Pratt, Chapel Hill.
Colorado......	R. D. George, Director, Boulder.	N. Dakota....	A. G. Leonard, Fargo.
Florida.......	E. H. Sellards, Tallahassee.	Ohio.........	J. A. Bownocker, Columbus.
Georgia.......	S. W. McCallie, Atlanta.	Oklahoma....	C. W. Shannon, Norman.
Illinois........	F. W. DeWolf, Director, Urbana	Pennsylvania .	Richard R. Hice, Beaver.
Indiana.......	Edward Barrett, Indianapolis.	Rhode Island..	Chas. W. Brown, Providence.
Iowa.........	Geo.F.Kay, Des Moines	S. Carolina....	Earle C. Sloan, Charleston.
Kansas.......	W. H. Twenhofel, Lawrence.	S. Dakota.....	Freeman Ward, Vermillion.
Kentucky.....	J. B. Hoenig, Frankfort.	Tennessee.....	A. H. Purdue, Nashville.
Maryland.....	William Bullock Clark, Baltimore.	Texas........	J. A. Udden, Austin.
Michigan......	R. C. Allen, Lansing.	Vermont......	G. H. Perkins, Burlington.
Minnesota....	W. H. Emmons, Minneapolis.	Virginia......	Thos. L. Watson, Charlottesville.
Mississippi....	E. N. Lowe, Jackson.	Washington...	Henry Landes, Seattle.
Missouri......	H. A. Buehler, Rolla.	West Virginia.	I. C. White, Morgantown.
Nebraska.....	E. H. Barbour, Lincoln.	Wisconsin.....	W. O. Hotchkiss, Madison.
New Jersey...	H. B. Kümmel, Trenton.	Wyoming.....	L. W. Trumbull, Cheyenne.

STATE MINE INSPECTORS, COMMISSIONERS, ETC.

State.	Name and Address.
Alabama...............	C. H. Nesbit, Chief Mine Inspector, Birmingham.
Alaska.................	Summer S. Smith, Mine Inspector, Juneau.
Arizona...............	G. H. Bolin, State Mine Inspector, Phoenix. Charles F. Willis, Director, State Bureau of Mines.
Arkansas..............	John H. Page, Commissioner, Bureau of Mines, Manufactures and Agriculture, Little Rock; John T. Fuller, State Mineralogist; Tom Shaw, State Mine Inspector, Midland.
California..............	F. McN. Hamilton, State Mineralogist, San Francisco.
Colorado...............	Fred Carroll, Commissioner, James Dalrymple, State Inspector of Coal Mines, Denver.
Idaho..................	R. N. Bell, State Mine Inspector, Boise.
Indiana.................	Michael Scollard, Deputy Inspector, of Mines, Indianapolis.
Iowa..................	E. M. Gray, Pres. State Mining Board, Des Moines.
Kansas.................	John Pellegrino, Chief Mine Inspector, Pittsburgh.
Kentucky..............	C. J. Norwood, Chief Inspector of Mines, Lexington.
Maryland..............	Wm. Walters, State Mine Inspector, Midland.
Minnesota	F. A. Wildes, State Mine Inspector, Hibbing.
Missouri...............	George Bartholomaeus, Secretary, Bureau of Mines and Mines Inspection, Jefferson City. George Hill, Chief Mine Inspector, Bevier.
Montana..............	W. B. Orem, State Mine Inspector. Helena.
Nevada................	A. J. Stinson, State Mine Inspector, Carson City.
New Mexico...........	Rees H. Beddow, Mine Inspector Gallup.
New York.............	W. W. Jones, State Mine Inspector, Albany.
North Dakota.........	Jas. W. Bliss, State Engineer, Bismark.
Ohio..................	J. M. Roan, Chief Deputy, Division of Mines, Columbus.
Oklahoma..............	Ed. Boyle, Chief Inspector, McAlester.
Oregon................	H. M. Parks, Director, Bureau of Mines, Corvallis.
Pennsylvania...........	James Roderick, Chief Department of Mines, Harrisburg.
South Dakota..........	O. E. Ellerman, State Mine Inspector, Lead.
Tennessee.............	R. A. Shiflett, Chief Mine Inspector, Nashville.
Texas.................	I. J. Broman, State Mine Inspector, Austin.
Utah..................	J. E. Pettit, State Mine Inspector, Salt Lake City.
Virginia...............	Capt. Richard B. Roane, Mine Inspector, Richmond.
Washington............	Jas. Bagley, State Inspector of Coal Mines, Seattle.
West Virginia..........	Earl Henry, Chief, Department of Mines, Charleston.

VALUE OF FOREIGN COINS

ESTIMATE BY DIRECTOR OF THE MINT, JAN. 1, 1916.

Country.	Standard.	Monetary Unit.	Value in Terms of U.S. Gold Dollar.	Coins.
Argentine Republic.	Gold	Peso	$0.965	Gold: argentine ($4.824) and ½ argentine. Silver: peso and divisions. Currency: Depreciated paper, convertible at 44 per cent. of face value.
Austria-Hungary	Gold	Crown	.203	Gold: 10 and 20 crowns. Silver, 1 and 5 crowns. Member of Latin Union; gold is the actual standard.
Belgium	Gold	Franc	.193	Gold: 10 and 20 francs. Silver: 5 francs.
Bolivia	Gold	Boliviano	.389	Silver: boliviano and divisions, 12½ bolivianos equal 1 pound sterling.
Brazil	Gold	Milreis	.546	Gold: 5, 10 and 20 milreis. Silver: ½, 1 and 2 milreis. Currency: Government paper. Exchange rate about 25 cts. to the milreis.
British Colonies in America.	Gold	Dollar	1.000	
in Australasia and Africa.	Gold	Pound sterling	4.8665	
Central America. Costa Rica.	Gold	Colon	.465	Gold: 2, 5, 10 and 20 colons ($9.307) Silver: 5, 10, 25 and 50 centimos.
British Honduras.	Gold	Dollar	1.000	
Nicaragua	Gold	Cordoba	1.000	
Guatemala, Honduras, Salvador	Silver	Peso	.384	Silver: peso and divisions. Guatemala: Currency, inconvertible paper, exchange rate 16 to 18 pesos = $1.00. Honduras: Currency, bank notes. Salvador: Currency, convertible into silver on demand.
Chile	Gold	Peso	.365	Gold: escudo ($1.825), doubloon ($3.650), and condor ($7.300). Silver: peso and divisions. Currency: Inconvertible paper; exchange rate, approximately, $0.14.
China	Silver	Tael: Amoy	.6296	
		Canton	.6277	
		Cheefoo	.6022	
		Chin Kiang	.6151	
		Fuchau	.5824	
		Haikwan (customs)	.6406	
		Hankow	.5891	
		Kiaochow	.6101	
		Nankin	.6230	
		Niuchwang	.5905	
		Ningpo	.6054	
		Peking	.6138	
		Shanghai	.5751	
		Swatow	.5816	
		Takau	.6336	
		Tientsin	.6101	
		Dollar Yuan	.4126	
		Dollar: Hongkong	.4141	
		British	.4141	
		Mexican	.4172	
Colombia	Gold	Dollar	1.000	Gold: condor ($9.647) and double condor. Silver: peso. Currency: Inconvertible paper; exchange rate, approximately, $102 paper to $1 gold.
Cuba	Gold	Peso	1.000	
Denmark	Gold	Crown	.268	Gold: 10 and 20 crowns.
Ecuador	Gold	Sucre	.487	Gold: 10 sucres ($4.8665). Silver: sucre and divisions.

NOTE.—The coins of silver-standard countries are valued by their pure silver contents, at the average market price of silver for the three months preceding January 1, 1916.

Country.	Standard.	Monetary Unit.	Value in Terms of U.S.Gold Dollar.	Coins.
Egypt...........	Gold...	Pound (100 piasters)..	4.943	Gold: pound (100 piasters), 5, 10, 20 and 50 piasters. Silver: 1, 2, 5, 10 and 20 piasters. The actual standard is the British pound sterling, which is legal tender for 97½ piasters.
Finland..........	Gold...	Mark...............	.193	Gold: 20 marks ($3.859), 10 marks ($1.93).
France...........	Gold...	Franc...............	.193	Gold: 5, 10, 20, 50 and 100 francs. Silver 5 francs. Member of Latin Union; gold is the actual standard.
German Empire....	Gold...	Mark...............	.238	Gold: 5, 10 and 20 marks.
Great Britain.....	Gold...	Pound sterling.......	4.8665	Gold: sovereign (pound sterling) and ½ sovereign.
Greece...........	Gold...	Drachma............	.193	Gold: 5, 10, 20, 50 and 100 drachmas. Silver: 5 drachmas. Member of Latin Union; gold is the actual standard.
Haiti.............	Gold...	Gourde.............	.965	Gold: 1, 2, 5 and 10 gourdes. Silver: gourde and divisions. Currency: Inconvertible paper; exchange rate, approximately, $0.2941.
India (British)....	Gold...	Pound sterling*......	4.8665	Gold: sovereign (pound sterling). Silver: rupee and divisions.
Italy............	Gold...	Lira................	.193	Gold: 5, 10, 20, 50 and 100 lire. Silver: 5 lire. Member of Latin Union; gold is the actual standard.
Japan............	Gold...	Yen..............	.498	Gold: 5, 10 and 20 yen. Silver: 10, 20 and 50 sen.
Liberia...........	Gold...	Dollar..............	1.000	Currency: Depreciated silver token coins. Customs duties are collected in gold.
Mexico..........	Gold...	Peso†................	1.498	Gold: 5 and 10 pesos. Silver: dollar‡ (or peso) and divisions. Mexican exchange rate fluctuating and uncertain.
Netherlands......	Gold...	Florin..............	.402	Gold: 10 florins. Silver: 2½, 1 florin, and divisions.
Newfoundland....	Gold...	Dollar..............	1.014	Gold: 2 dollars ($2.027).
Norway..........	Gold...	Crown..............	.268	Gold: 10 and 20 crowns.
Panama..........	Gold...	Balboa..............	1.000	Gold: 1, 2½, 5, 10 and 20 balboas. Silver: peso and divisions.
Paraguay	Silver .	Peso................	.384	Currency: Depreciated paper, exchange rate 1550 per cent.
Persia...........	Silver.	Kran‡‡............	.0875	Gold: ½, 1, and 2 tomans ($3.409). Silver: ¼, ½, 1, 2 and 5 krans.
Peru.............	Gold...	Libra...............	4.8665	Gold: ½ and 1 libra. Silver: sol and divisions.
Philippine Islands.	Gold...	Peso................	.500	Silver peso: 10, 20 and 50 centavos.
Portugal.........	Gold...	Milreis.............	1.081	Gold: 1, 2, 5 and 10 milreis.
Roumania........	Gold...	Leu.................	.193	Currency: Inconvertible paper; exchange rate, approximately, $0.9394.
Russia...........	Gold...	Ruble..............	.515	Gold: 5, 7½, 10 and 15 rubles. Silver: 5, 10, 15, 20, 25, 50 and 100 copecks.
Santo Domingo...	Gold...	Dollar	1.000	....
Servia...........	Gold...	Dinar...............	.193	....
Siam............	Gold...	Tical................	.371	....
Spain............	Gold...	Peseta..............	.193	Gold: 25 pesetas. Silver: 5 pesetas. Valuation is for the gold peseta; currency is silver circulating above its metallic value, approximately, $0.1794.
Straits Settlement.	Gold...	Pound sterling§......	4.8665	Gold: sovereign (pound sterling). Silver: dollar and divisions.
Sweden..........	Gold...	Crown..............	.268	Gold: 10 and 20 crowns.
Switzerland.......	Gold...	Franc...............	.193	Gold: 5, 10, 20, 50 and 100 francs. Silver: 5 francs. Member of Latin Union; gold is the actual standard.
Turkey..........	Gold...	Piaster.............	.044	Gold: 25, 50, 100, 250 and 500 piasters. 100 piasters equal to the Turkish £.
Uruguay.........	Gold...	Peso................	1.034	Gold: peso. Silver: peso and divisions.
Venezuela........	Gold...	Bolivar.............	.193	Gold: 5, 10, 20, 50 and 100 bolivars. 5 bolivars.

* The sovereign is the standard coin of India, but the rupee ($0.3244⅓) is the current coin, valued at 15 to the sovereign.

† Seventy-five centigrams fine gold.

‡ Value in Mexico, $0.498.

‡‡ The Gold Kran $0.1704.

§ The current coin of the Straits Settlements is the silver dollar issued on Government account, and which has been given a tentative value of $0.5678.

SOME FOREIGN WEIGHTS AND MEASURES AND THE U. S. EQUIVALENTS[1]

1 almude (Portugal)	= 4.422 gal.
1 arobe (Paraguay)	= 25 lb.
1 arroba, dry (Argentine)	= 25.3171 lb.
1 arroba, liquid (Cuba, Spain, Venezuela)	= 4.263 gal.
1 arshine (Russia)	= 28 in.
1 sq. arshine (Russia)	= 5.44 sq. ft.
1 baril (Argentine, Mexico)	= 20.079 gal.
1 braca (Brazil)	= 2.407 yards.
1 bu (Japan)	= 0.119305 in.
1 candy (India)	= 529 lb.
1 catty (China)	= 1.333 lb.
1 catty (Japan)	= 1.323 lb.
1 catty (Java)	= 1.356 lb.
1 catty (P. I.)	= 1.39 lb.
1 catty (Str. Sett.)	= 1.333 lb.
1 catty (Sumatra)	= 2.118 lb.
1 centaro (Central America)	= 4.2631 gal.
1 chih (China)	= 1.049867 ft.
1 cho (Japan)	= 357.916 ft.
1 cuadra (Argentine)	= 4.2 acres
1 dessiatine (Russia)	= 2.6997 acres
1 doli (Russia)	= 0.685 grains
1 fanega (Argentine)	= 3.89 bu.
1 fen (China)	= 0.12598 in.
1 fen (sq.) (China)	= 0.015181 acres
1 funt (Russia)	= 0.9028 lb. = 409 grams
1 go (Japan)	= 1.270506 gill liquid = 0.0198517 peck dry
1 hao (China)	= 0.001260 in.
1 sq. hao (China)	= 0.00015181 acres
1 jo (Japan)	= 3.31404 yd.
1 ken (Japan)	= 1.983427 yd.
1 kin (Japan)	= 1.32277 lb. Avoir.
1 koku (Japan)	= 39.7033 ga. liquid = 4.96291 bu. dry
1 kwan (Japan)	= 8.26733 lb. Avoir.
1 legua (Brazil)	= 4.102 miles
1 li (China)	= 0.012598 in.
1 liang (China)	= 1.31561 oz. Avoir.
1 lyi (China)	= 0.0015181 acres
1 manzana (Costa Rica)	= 1.625 acres
1 marc (Bolivia)	= 0.507 lb.
1 maund (Bengal)	= 82.2855 lb.
1 maund (Bombay)	= 28 lb.
1 maund (Madras)	= 25 lb.
1 meou (China)	= 0.15181 acres
1 milla (Nicaragua, Honduras)	= 1.1493 miles
1 momme (Japan)	= 2.4123045 dwt.
1 pie (Argentine)	= 0.9478 ft.
1 pikul (Borneo)	= 135.6354 lb.
1 pikul (China)	= 133⅓ lb.
1 pikul (Japan)	= 132.277 lb.
1 pikul (Java)	= 135.6 lb.
1 pikul (P. I.)	= 139.485 lb.
1 pikul (Str. Sett.)	= 133⅓ lb.
1 pood (Russia)	= 36.1128 lb.
1 pulgada (Argentine)	= 0.947 in.
1 quintal (Argentina)	= 101.28 lb.
1 quintal (Bolivia, Chile, Colombia, Dominican, Repub., Spain)	= 101.4 lb.
1 quintal (Brazil)	= 129.526 lb.
1 quintal (Costa Rica)	= 101.465 lb.
1 quintal (Syria, Turkey)	= 125 lb.
1 ri (Japan)	= 2.440338 mi.
1 ri (marine) (Japan)	= 1.1506873 mi.
1 sagene (Russia)	= 7 ft.
1 sashen (Russia)	= 7 lb.
1 shaku (Japan)	= 11.9305424 in.
1 sheng (China)	= 2.7354 liq. gal.
1 sho (Japan)	= 1.5881325 qt. liquid = 0.1985166 pecks dry
1 sun (Japan)	= 1.1930542 in.
1 tan (Japan)	= 0.24507 acre
1 tch'e (China)	= 12.598 in.
1 tchetvert (Russia)	= 117,600 sq. ft.
1 to (Japan)	= 3.9703313 gal. liquid
1 ts'onen (China)	= 1.2598 in.
1 tsubo (Japan)	= 3.95329 sq. yd.
1 vara (Argentine)	= 34.1208 in
1 verchok (Russia)	= 1.75 in.
1 verst (Russia)	= 3,500 ft.
1 zolotnik (Russia)	= 658 grains

[1] From Liddell's Metallurgists and Chemists' Handbook, pp. 13–15.

CONTENTS OF VOLUME XXIV

Special Chapters

INTRODUCTION

The object of MINERAL INDUSTRY is to bring together as complete a record as possible of the year's progress in the mining and metallurgical industries in all the important producing countries and to give to the reader a general view of the entire field so far as information is available. Of course it is impossible to treat at any great length any of the various subjects, simply for lack of space. It is our desire, however, to combine the leading statistics of production in the various localities with such extracts from the current technical literature as have a bearing on the subject in hand, and sufficient discussion of prevailing commercial conditions to show the trend of the financial side of the industry.

So far as it is possible, the information includes the various countries of the world producing important quantities of a given material. However, it must be borne in mind that conditions are such at present as to prevent the dissemination of information of any kind from many producing localities. This sometimes necessitates the treatment of an important district in a very brief manner, not from any desire to slight the importance of the district, but simply from lack of information. It is a question of relative availability of reliable, up-to-date information concerning the various fields, and naturally, those nearest home have the advantage.

In order to make the reports representative and authoritative, their preparation, so far as possible, has been turned over to specialists, the reader, in this way, getting the benefit not only of the items of information included in the report, but also of that expert's judgment concerning the relative importance of the information. The results obtained in this way are much more reliable and satisfactory than could be obtained in a scissors-and-paste compilation by the editor, who could not possibly be acquainted with conditions in more than a few fields.

A number of mineral industries, particularly those connected with the pottery and building trades, are so widely scattered that their treatment is beyond the scope of a general report of this kind. A few industries relating to manufactured material are included, where the production of the manufactured material is closely associated with that of the raw material, or where it is replacing to a considerable extent some natural material, *e.g.*, coke and cement.

The statistics presented are of the best available at the time of publication. Wherever possible they are the official figures of the country in question. Where it is known, the source of the statistics is shown. When conditions are at their best, there is great difficulty in getting even approximately complete statistics within a few months after the close of the year. At this time the European war makes the collection of statistics much more difficult and, in many cases, entirely impossible. For this reason the statistical side of the present volume will not be found quite so complete along some lines as the preceding ones. This also applies in some cases to general information as well, for almost nothing at all could be learned concerning some producing localities.

For many of the production statistics we are indebted to the U. S. Geological Survey, and to the corresponding departments of the various foreign countries; for the United States imports and exports, to E. E. Pratt, Chief of the Bureau of Foreign and Domestic Commerce. Acknowledgment is also due to many of the State Geological Surveys and Mining Bureaus for statistical and general information.

In most cases, the sources of information are shown either in the text or in footnotes; any variation from this rule is an unintentional oversight.

Our indebtedness to the columns of the technical press is gratefully acknowledged, particularly to *Engineering and Mining Journal*, *Mining and Scientific Press*, *Metallurgical and Chemical Engineering*, *Mining and Engineering World*, *Coal Age*, *Salt Lake Mining Review*, *Mining Journal*, *Mining Magazine*, *Canadian Mining Journal*, and *South African Mining Journal*.

The make-up of the volume is similar to that of preceding volumes, the various industries being taken up in alphabetical order, except in cases where similar materials are classed under a general heading, *e.g.*, Abrasives. In the latter part of the volume will be found articles of general interest. The statistical tables at the end are made up from the official reports of the various countries. As these are often a year or more behind, the tables are completed to date, so far as possible, with unofficial figures. This will undoubtedly increase the value of the tables, even though some of the figures given are only approximately correct. All unofficial figures in the tables are given in full-face type to distinguish them from the official figures. The index has been made as detailed as possible, considering the space that can be devoted to it, and all items are thoroughly cross-indexed.

As indicated on the title page, this volume is a supplement to Volumes I–XXIII, but at the same time it is more than a supplement. It not only adds the data for the year 1915, but also gives corrections of the figures incorporated in previous volumes. Hence, it is important in using

Mineral Industry always to use the latest volume, even for figures for previous years, in order to get the benefit of these corrections, except, of course, in the case of the less important statistics, which are not carried from year to year, but are given only once.

In conclusion, the Editor expresses his gratitude and indebtedness to the Contributors of the various articles incorporated in this volume for their hearty coöperation, for to them is due a large measure of the credit for whatever of value the volume may contain.

G. A. Roush.

South Bethlehem, Pa.
July, 1, 1916.

ABRASIVES

By J. Volney Lewis

As in former years, the chief dependence for abrasives employed in the metal-working industries in 1915 has been imported emery and corundum and the two important classes of artificial abrasives—silicon carbide (carborundum, crystolon) and artificial corundum (alundum, aloxite). No domestic corundum has been produced since 1906 and the emery mines at Chester, Mass., have not been operated since 1912. Mining is said to have been more active and continuous, however, in the Peekskill district, New York, during 1915 than for several years past. So far as has been ascertained there was no other domestic emery or corundum on the market.

The demand for abrasive has been greatly stimulated during the year by the increasing activities of the metal trades, while at the same time the supplies of both Smyrna and Naxos emery have been practically cut off by the operations of the war in Europe, so that importations have become increasingly difficult, expensive, and uncertain. The production of Canadian corundum has also been seriously curtailed since the destruction of the principal mill by fire in 1913. These conditions have given still greater importance during the year to the artificial abrasives, which for more than a decade have been steadily encroaching upon the markets of the natural products.

Markets.—With rapidly increasing demands and diminishing stocks the prices of abrasives have advanced sharply during the year, some quotations for grains in small amounts ranging as much as 50 per cent. or more above the prices at the beginning of the year. The stimulus was also felt in the market for artificial abrasives, and at the close of the year it was said that orders were being booked many weeks in advance of the capacity of the plants.

The following table shows the relative importance of the chief natural and artificial abrasives employed in the metal industries of the United States from 1905 to 1915.

A part of these materials, both natural and artificial, are exported every year, chiefly in manufactured form; similar manufactures are

NATURAL AND ARTIFICIAL ABRASIVES IN THE UNITED STATES[1]
(Short tons)

	Domestic. Garnet.	Domestic. Emery and Corundum.	Imported Emery and Corundum.	Total Mineral Abrasive.	Alundum, etc.	Carborundum, etc.	Total Artificial.	Per Cent. Artificial.
1906.....	4,650	1,160	17,829	23,639	2,166	3,113	5,279	18.3
1907.....	7,058	1,069	14,724	22,851	3,376	3,766	7,142	23.8
1908.....	1,996	669	9,922	12,587	1,580	2,454	4,034	24.3
1909.....	2,972	1,580	12,364	16,916	6,789	3,239	10,028	37.2
1910.....	3,814	1,028	33,576	38,418	6,705	5,354	12,059	23.4
1911.....	4,076	659	12,878	17,613	5,558	5,188	10,746	37.9
1912.....	4,947	992	19,425	25,364	6,633	6,021	12,654	33.3
1913.....	5,308	957	20,425	26,690	10,102	6,299	16,401	38.1
1914.....	4,231	485	14,457	18,968	10,419	5,411	15,830	45.5
1915.....	4,301	3,063	10,116	17,480	(e)11,000	5,460	16,460	48.5

(e) Estimated.

also imported, but are not included in the above table. Some of the emery is used in the manufacture of aloxite, and the artificial products are being imported in increasing amounts in recent years.

Imports.—Nearly all the crude emery comes from Asiatic Turkey, the principal mines being located from 50 to 200 miles southeast of Smyrna. There was a great falling off in importations during 1915, and before the close of the year emery was difficult to obtain and the supplies uncertain. As compared with 1914 the decrease in rock emery was 34 per cent. and that of grains 25 per cent. Corundum, which is imported chiefly from Canada, showed an even greater decline, the ore and grains brought in being 39 and 37 per cent., respectively, less than the corresponding imports for 1914. The comparison is shown in detail in the following table.

IMPORTS OF CORUNDUM AND EMERY IN 1914 AND 1915[2]

	Corundum. Ore (Long Tons).	Corundum. Grains (Pounds).	Emery. Ore (Long Tons).	Emery. Grains (Pounds).	Totals (Long Tons).
1914.............	246	1,120,147	12,662	761,674	13,703
1915.............	149	707,034	8,313	569,639	9,031
Decrease	97 39%	413,113 37%	4,349 34%	192,035 25%	4,672 34%

The combined imports of corundum and emery in the forms of grains, ore, and rock are shown in the following table, for the years 1905 to 1915.

[1] Domestic natural abrasives, U. S. Geol. Surv.; artificial, MINERAL INDUSTRY. All reduced to short tons for comparison.
[2] Compiled from reports of the Bureau of Foreign and Domestic Commerce.

IMPORTS OF CORUNDUM AND EMERY, 1906-1915[1]

	Grains.		Ore and Rock.		Manufactures, Value.	Total Value.
	Pounds.	Value.	Long Tons.	Value.		
1906	$4,655,668	$215,357	$13,841	$286,386	$19,339	$521,082
1907	4,282,228	186,156	11,235	211,192	15,282	412,630
1908	1,735,366	89,702	8,084	146,105	15,592	248,399
1909	2,696,960	132,264	9,836	186,930	19,803	338,997
1910	2,311,464	106,570	28,948	509,661	13,527	629,758
1911	1,382,813	76,027	10,822	245,459	15,158	336,644
1912	2,135,922	105,325	16,391	369,529	16,871	491,725
1913	2,496,372	114,786	17,123	342,809	16,704	474,299
1914	1,781,821	79,989	12,909	280,876	22,581	383,446
1915	1,276,673	56,254	8,462	197,303	18,092	271,649

The relative importance of corundum imports from Canada, as compared with those from other countries, chiefly India, is shown in the following table, which also emphasizes the marked decline in Canadian corundum in the past 2 years.

CORUNDUM IMPORTED FROM CANADA AND OTHER COUNTRIES[2] 1911-1915, YEARS ENDING JUNE 30

	Ore and Rock.				Grains.			
	Canada.		Other Countries.		Canada.		Other Countries.	
	Long Tons.	Value.	Long Tons.	Value.	Pounds.	Value.	Pounds.	Value.
1911	424	$51,533	413	$11,507	1,566,100	$79,979	30,440	$1,133
1912	573	71,971	8	687	624,700	37,706	32,329	1,756
1913	421	61,953	120	16,448	1,872,500	83,275	65,303	3,912
1914	168	23,970	126	15,802	659,200	40,767	454,851	20,259
1915	149	21,136	34	2,565	607,500	31,464	223,844	8,450

Exports.—The total values of abrasives exported in the past 3 years are shown in the following tables, compiled from the reports of the Bureau of Foreign and Domestic Commerce. It will be noted that the value of wheels exported in 1915 increased 109 per cent. over that of 1914.

ABRASIVES EXPORTED FROM THE UNITED STATES 1913-1915

	1913.	1914.	1915.
Wheels, emery and other	$731,297	$572,218	$1,200,303
All other	1,551,892	1,123,505	1,403,808
Totals	$2,283,189	$1,695,723	$2,604,121

[1] Statistics for 1905-1913 from the U. S. Geological Survey; for 1914 and 1915 from Bureau of Foreign and Domestic Commerce.
[2] Bureau of Foreign and Domestic Commerce.

DISTRIBUTION OF ABRASIVES EXPORTED FROM THE UNITED STATES
(For the year ending June 30, 1915)

	Wheels.	All Other.	Totals.
Great Britain	$326,076	$437,636	$763,712
Canada	57,752	174,972	232,731
France	121,003	40,215	161,218
Australia	31,987	78,821	110,808
Denmark	17,505	66,175	83,680
Sweden	35,888	31,809	67,697
Japan	43,431	18,997	62,428
All others	67,548	208,605	276,153
Totals	$736,879	$1,065,369	$1,802,242

Corundum Mining in Ontario

Dr. Barlow's valuable and comprehensive monograph[1] on corundum covers the chemistry, mineralogy, geology, technology, and literature of this mineral throughout the world, but with special reference to the great series of corundum-bearing rocks in Ontario. The following notes are condensed from this publication.

History.—Following the discovery of corundum in Hastings County, Ontario, in 1896,[2] the mining of this mineral began with the production in 1900 of about 60 tons of graded grain corundum, of which only 3 tons were shipped. In the following year 444 tons were produced, and in 1903 the output was nearly doubled, 806 tons having been cleaned and graded. The maximum production, 2914 tons, was reached in 1906, of which 2274 tons, valued at $204,973, were sold. The industrial depression of 1907 caused a still greater discrepancy between production and sales and 790 tons were left in stock. A better balance has been preserved since 1909, and in 1912 1960 tons of grain corundum were sold for $239,091, the largest annual value since the establishment of the industry. Of this large amount all but 32 tons was exported. Up to the end of 1913 the total value of corundum produced amounted to nearly $2,000,000.

The Canada Corundum Co., the pioneer, began active mining development in April, 1900, with an experimental mill of 20 tons capacity daily. A 200-ton mill was built 3 years later. In the meantime several other companies were organized and began operations, some of them erecting mills, in which various methods of crushing and concentration were employed. All of these were combined in 1909 under the Manufacturers Corundum Co. and production was maintained on a large scale until the

[1] "Corundum, its Occurrence, Distribution, Exploitation, and Uses," By A. E. Barlow, Canada Department of Mines, Geological Survey, *Memoir* 57, Ottawa, 1915; 378 pages, elaborately illustrated with maps and plates. See also abstract, *Can. Min. Jour.*, Jan. 15, 1915, pp. 379–382.

[2] According to Mr. H. M. Ami, the discovery dates back to 1893 or earlier. See *Can. Min. Jour.*, Aug. 15, 1916.

destruction of their principal mill (at Craigmont) by fire in February, 1913, which brought about serious curtailment.

Difficulties.—The industry has labored under serious disadvantages from the beginning, among which the problems of concentration and preparation for market were perhaps the greatest. Almost from the start also the competition of the artificial abrasives, carborundum and, a little later, alundum, was keenly felt. Transportation and labor problems also proved difficult and expensive.

Corundum-bearing Areas.—The belts of corundum-bearing rocks are situated close to the edge of the great Canadian shield of pre-Cambrian rocks about midway between Ottawa and Toronto, with the center of the mining industry at Craigmont. The deposits occur in the northern townships of Peterborough and Hastings and the southern part of the adjoining counties of Haliburton and Renfrew. There are three distinct bands, the longest of which, with interruptions, is about 103 miles in a northeast and southwest direction, with a maximum width of nearly 6 miles. The others, with a similar direction, are 8 and 12 miles long, respectively, and the distances between the bands are approximately 25 and 50 miles. These are considered the most extensive developments of corundum-bearing rocks known. The rocks are chiefly of syenitic type, with gabbroic and dioritic facies, and show an extreme and rapid variation in composition. It is believed that no other class of rocks shows an equally great diversity of types within such short distances. They are differentiation products of a highly aluminous magma and represent a single geologic unit, constituting the marginal facies of the Laurentian granite-gneisses where these intrude the crystalline limestones of the Grenville series.

Future Supplies.—Almost coincident with the fire disaster, although more slowly realized, came the conviction that the corundum deposits of Craigmont (Robillard Mountain), which were at first thought to be inexhaustible, had reached a stage when it was both difficult and expensive to obtain a sufficient supply of the desirable quality of ore. The decision that such ore is by no means abundant on this hill has been reached by reason of rather extensive drilling and tunneling operation combined with the knowledge gained in the operation of the large excavations or quarries. There is, however, a considerable supply of good corundum ore in the deposits north and west of the Burgess mines in Carlow township. Other deposits of corundum which are regarded as of commercial grade and size occur in the vicinity of Palmer rapids, in the northeastern part of Raglan township. These likewise have the advantage of convenient location to existing means of transportation. Deposits of very distinct promise occur in Brudenell township and in the northwest corner of Faraday township. The mill tests of the materials secured from the Monteagle and Dungannon localities, in the vicinity of York River, are said to have been disappointing.

The Outlook.—Transportation will again largely determine the scene of future operations. Competition of artificial abrasives has no doubt lessened the demand and price for natural corundum, but in spite of these there is always a ready demand for the natural product, especially in times of industrial activity. The future of the industry, although uncertain, is by no means without hope.

Production.—The production and value of corundum in Canada are given in the following table for the years 1910 to 1915.

PRODUCTION OF CORUNDUM IN CANADA, 1910–1915[1]

	Tons.	Value.	Average per Ton.
1910	1,870	$171,994	$91.98
1911	1,471	147,158	100.04
1912	1,960	233,212	119.00
1913	1,177	137,036	116.42
1914	548	65,730	119.96
1915	262	31,398	119.84

Greek Sales of Emery[2]

According to information obtained from the foreign office, future sales of emery will be divided between the United States, England, and France. Preference will be given to firms known to the Government. American firms should be advised to fix the quantities they desire and to appoint representatives at Athens and Syra and a bank at Athens to make payments.

The Greek production during 1914 amounted to 16,112 metric tons, and sales amounted to 10,226 tons. The 1915 production is estimated at 15,000 tons.

Corundum in India[3]

For many generations there has been a certain trade in Indian corundum, but the returns are incomplete. No workings exist of the kind that could be ordinarily described as mines, but attempts have been made to increase the scale of operations at Palakod and Paparapatti in the Salem district, near Hunsur in Mysore, and in South Rewah. Much of the corundum which is a regular item of trade in the bazaars of cities like Delhi, Agra, and Jaipur, where the Indian lapidary still flourishes, is collected in a casual way by agriculturists and cowherds, who dispose

[1] From reports of the Ontario Bureau of Mines.
[2] *Comm. Rept.*, Apr. 19, 1916.
[3] A. E. Barlow, *loc. cit.*, p. 314.

of it through the village "bania" to the larger dealers of the great cities. The greater part of the increased production of Indian corundum in recent years has come from Mysore, Madras, and Assam.

Malayan Corundum in Core Drilling[1]

Corundum found in the Kintna valley in Perak was recently utilized in boring. The crown of a diamond drill was lost with the diamonds fitted to it and an attempt was made to use fragments of corundum as a substitute. A bowlder of the best corundum obtainable was broken into angular fragments of approximately ⅛ in. diam. Six fragments were fitted in a crown and the results are reported to have compared most favorably with a calyx head and chilled shot. The corundum was found to be somewhat brittle and was calked with pieces of soft copper to obtain the best results.

Artificial Abrasives

Two classes of artificial abrasives compete directly with corundum and emery in the metal-working industries. These are silicon carbide (carborundum, crystolon) and artificial corundum or crystallized alumina (alundum, aloxite). The rapidly growing importance of these products in the last decade is strikingly shown in the following table.

PRODUCTION OF CARBORUNDUM AND ALUMINOUS ABRASIVES IN THE UNITED STATES, 1905–1915

Aluminous Abrasives.			Carborundum.		Totals.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1905	3,612,000	$252,840	5,596,280	$391,740	9,208,280	$644,580
1906	4,331,233	303,186	6,225,280	435,770	10,556,513	738,956
1907	6,751,444	405,086	7,532,670	451,960	14,284,114	857,046
1908	3,160,000	189,600	4,907,170	294,430	8,067,170	484,030
1909	13,578,000	814,680	6,478,290	388,697	20,056,290	1,204,377
1910	13,410,000	804,600	10,707,110	642,427	24,117,110	1,447,027
1911	11,116,000	666,960	10,376,620	622,597	21,492,620	1,289,557
1912	13,266,486	795,989	12,042,550	722,553	25,309,046	1,518,542
1913	20,203,600	1,212,216	12,597,590	692,867	32,801,190	1,905,083
1914	21,839,090	1,310,345	10,821,530	595,184	32,660,620	1,905,529
1915	22,000,000	....	10,919,770	600,587	32,919,770	....

A marked increase is also seen in imports of artificial abrasives, both from Canada and from Europe, as shown in the following table.

IMPORTS OF ARTIFICIAL ABRASIVES 1911–1915
(Years ending June 30)

	1911.	1912.	1913.	1914.	1915.
From Canada	$38,696	$73,666	$88,809	$84,623	$150,885
From Europe	10,921	14,884	101,481	149,176	104,589
Totals	49,617	88,550	190,290	233,799	255,474

[1] *Min. Jour.*, June 12, 1915.

Pebbles for Grinding in the United States[1]

The metallurgy of gold and silver ores, the manufacture of cement, and the grinding of feldspar, quartz, and mineral pigments are dependent in large measure on the use of pebble mills for pulverizing, and these have used chiefly flint pebbles imported in the main from Denmark, France, and Belgium. Since the war in Europe has made it difficult to obtain an adequate supply of these pebbles and has caused a sharp advance in prices, efforts have been made to find a domestic supply of flint pebbles or a suitable substitute.

Pebbles of granite, quartzite, and other material have long been imported from Newfoundland and Ontario, and some cement plants have heretofore used local stream and beach pebbles successfully. Late in 1913 Mr. Omar Maras, of Nevada, began the experimental manufacture of substitute pebbles, which has since met with considerable success. Sources of domestic flint pebbles are but imperfectly known. They occur in some of the Coastal Plain formations bordering the southern Appalachians and the Ozarks, but most of them are probably too small, few of them exceeding 2½ in. diam. Other possible sources are flint-bearing limestones of central Texas, particularly the Edwards limestone. Whether appropriate supplies of flint are found or not, the success of recent experiments with substitutes seems to be a herald of American independence. For example, selected, well-rounded quartz pebbles from stream gravels in Amador County, Cal., have been satisfactorily substituted for Danish pebbles in a gold mill, and one of the large California rock-dressing plants which handles dredge tailings in the gold placer fields is sorting pebbles suitable for this use. A cement mill on the Pacific coast is making large use of pebbles which are found in great quantities along the shore, and the results are said to be as good as those obtained with foreign pebbles. Pebbles from the north shore of Lake Superior and from Conception Bay, Newfoundland, largely quartzite and granite, have been supplied to cement grinders for many years. Numerous gravel deposits in the United States contain pebbles equally as good. Good rhyolite and basalt pebbles can be found in the Rocky Mountains and in the Pacific States, and granite pebbles are abundant on the flanks of the Sierra Nevada near many of the gold mills. On the eastern coast rhyolite and felsite are abundant from Marblehead, Mass., to Eastport, Me.

The manufacture of pebbles or balls from the natural rock has been tried at Manhattan, Nev., a dense silicified rhyolite, now called onyx, being used. The rock is broken into blocks of suitable size and rounded

[1] Summary of an article by Frank J. Katz, *Min. Res. of U. S.*, 1914, pp. 564–567.

by tumbling in a revolving chamber. The roughly rounded blocks have been tested in several of the large Tonopah mills and have been found quite as efficient as Danish flint pebbles. Another substitute is found in the use of chunks of flinty ore, and further experiments along this line are desirable. Angular blocks of basalt lava have been used in at least two instances. At a gold mine in eastern Oregon blocks from a mineralized dike were used with economical grinding results and at the same time the values in the trap rock were recovered. The cement mill of the U. S. Reclamation Service at Arrowrock dam used with entire satisfaction angular blocks of basalt collected along the line of the Arrowrock Railroad. The corners and edges of the blocks ground off quickly and the chunks were reduced to spherical or ellipsoidal forms.

Imports.—In the records of imports the pebbles that are to be used for grinding are not kept separate from those that are crushed and used as "flint" in the ceramic industry. Hence only the combined values are given in the following table. A large part of those from Denmark, Belgium, and France, however, are used in pebble mills for grinding other materials.

VALUE OF PEBBLES IMPORTED INTO THE UNITED STATES[1]

	1912.	1913.	1914.	1915.
Belgium	$99,472	$40,947	$70,851	....
Canada	14,141	8,599	63,996	$1,128
Denmark	78,123	134,625	193,029	152,129
England	870	2,626	2,199	1,303
France	99,140	121,854	116,571	91,024
Newfoundland and Labrador	....	10,800	8,448	....
Norway	239	....	1,846	....
Sweden	....	56	22,081	28,088
Other countries	67	2	125	97
Totals	292,052	319,509	479,146	273,769

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[1] U. S. Geol. Survey, 1912–1914; Bureau of Foreign and Domestic Commerce 1915.

Garnet

By D. H. Newland

The abrasive garnet industry experienced no marked changes last year, either as regards technology or its economic position. The Adirondack mines were worked on about the usual scale, though the production fell a little short of the total for the preceding year, amounting to 3900 short tons valued at $134,064. The value of the product was practically as large, however, owing to the increased proportion of high-grade crystal garnet in the total. For a number of years past the production has averaged around 4000 tons, and only twice in recent years has it exceeded 5000 tons. Prices vary with the quality of the product, but the best crystal garnet which comes from the North River district holds steadily at $35 a ton.

The active producers in the Adirondack region last season included the North River Garnet Co. with mines on Thirteenth Lake, H. H. Barton & Son Co., operating on Gore Mountain, and Warren County Garnet Mills at Riparius, all in Warren County. The property on Mount Bigelow, near Keeseville, in northern Essex County, recently worked by the American Garnet Co., was idle throughout the year. The resources of garnet in the Adirondack deposits are large and capable of yielding a much greater quantity than is now produced; it is not any lack of capital or enterprise on the part of the mining companies that holds the production down to the present proportions, but the market is strictly limited and shows little tendency to growth.

Outside of the Adirondacks garnet occurs in association with metamorphic rocks along the Appalachians from the New England States south to North Carolina and Alabama. The Highlands of southeastern New York belong to this mountain range, and in the vicinity of Peekskill, Westchester County, there are garnet deposits which have been worked in a small way. New Hampshire, Pennsylvania and North Carolina have yielded more or less of the mineral in recent years, but nowhere except in the Adirondacks has the mining industry attained any great importance.

The use of garnet as an abrasive has not made much headway in foreign countries. Spain is the only country of Europe which produces it in quantity and the output is sent to this country for manufacture. Spanish garnet is obtained from alluvial deposits which are found in the province of Almeria; it is of rather fine grain and only a partial substitute for the American product. The imports into the United States in 1915 were 1343 tons with a declared value of $24,472. There is no duty on abrasive garnet, and owing to the nature of the Spanish deposits the mineral can be produced at a cost which permits its importation in competition with the domestic product.

PRODUCTION OF ABRASIVE GARNET (*a*)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1904	3854	$117,581	1910	3814	$113,574
1905	5050	148,095	1911	4076	121,748
1906	4650	157,000	1912	4947	163,237
1907	7058	211,686	1913	5308	183,422
1908	1960	64,620	1914	4231	145,510
1909	2972	102,315	1915	4301	139,584

(*a*) U. S. Geol. Surv.
(*b*) New York alone.

ALUMINIUM

By J. W. Richards

The continuance of the European war has affected aluminium in common with all other metals. Immense activity has been in evidence in the United States, and it must be undoubtedly true that both the United States and Canada made in 1915 the largest production in their history. Of Europe, however, what little information is made public is contradictory and unsatisfactory. Even business men in America most keenly concerned in knowing the state of the industry in Europe admit that they do not know the actual conditions; and our correspondents in Europe from whom, in ordinary times, some information was to be obtained, either write nothing at all or else remark that the censor will not allow the usual information to pass out of their country. From glimmerings of information it seems probable that in the countries at war production has been restricted because of scarcity of labor but that it has not been very greatly reduced because of the large military uses which must be satisfied. It is a guess, but the only one possible, to estimate that the production in France declined 50 per cent., in Austria Hungary 50 per cent., in Italy 25 per cent., in Great Britain 20 per cent., in Switzerland an increase, in Norway an increase, in Canada its maximum production, and in the United States a 15 per cent. increase. In the absence of all official figures, therefore, we make the following estimates of the world's production in 1915:

Country.	Metric Tons.	Pounds.
United States	45,000	99,000,000
Canada	8,490	18,680,000
France	7,500	16,500,000
Great Britain	6,000	13,200,000
Norway	3,500	7,700,000
Switzerland	12,500	27,500,000
Austria Hungary	2,500	5,500,000
Italy	750	1,650,000
	86,240	189,730,000

Grouped by producers these figures would represent:

	Metric Tons.	Pounds.
Aluminum Co. of America / Northern Aluminum Co. of Canada	53,490	117,680,000
L'Aluminium Française	7,500	16,500,000
British Aluminium Co.	9,500	20,900,000
Aluminium Industrie Aktien Gesellschaft	15,000	33,000,000
Societé d'Aluminio, Italy	750	1,650,000

The conditions of 1915 were therefore favorable to the American branch of the aluminium industry increasing its lead over the producers of Europe. In 1914 America produced about 56 per cent. of the world's production, in 1915 probably over 61 per cent.; or, expressing it another way, the United States alone produces now more aluminium than all the rest of the world. The aluminium industry has become predominantly an American industry.

Imports of unmanufactured aluminium into the United States in 1915 were 3871 metric tons (8,534,834 lb.) valued at $1,511,988; of manufactured goods to the value of $301,863. These are less than half the 1915 figures, and only a little more than one-third the 1913 importations. The sources of these importations of ingot metal and scrap, as shown by the 1914 figures, are principally Canada, Switzerland, Great Britain, France, Germany, Austria and Norway, in the order named, in 1915 Canada supplied practically one-half of the whole quantity; while imports of scrap from Germany and Austria were almost entirely, stopped and imports of metal from Norway, France, and Great Britain constituted the bulk of the supply from Europe, Switzerland being reduced to 10 per cent. of its former amount.

The following table shows the distribution of imports according to country of origin, during the fiscal years ending June 30, 1913, 1914,

IMPORTS OF ALUMINIUM, 1913–1915
(By fiscal years ending June 30)

	1913, Pounds.	1914, Pounds.	1915, Pounds.
Austria Hungary	1,041,030	1,300,717	264,552
Belgium	834,928	227,563	194,708
France	2,580,447	2,081,468	1,798,127
Germany	8,314,908	1,632,226	11,133
Italy	720,992	8,816	....
Netherlands	482,122	....	....
Norway	380,800	1,173,800	2,046,168
Portugal	....	....	4,321
Switzerland	1,058,208	2,612,747	264,552
United Kingdom	4,822,180	2,110,257	1,675,616
Canada	6,722,401	4,816,067	7,499,313
Other countries	338	381	6,682
Total	26,958,354	15,964,042	13,765,172

and 1915. These figures, of course, do not coincide with the calendar year figures but they unquestionably show the trend of affairs.

The imports by months were quite regular in 1914, showing but little variation even after the opening of the war. However, in 1915 a pronounced reduction in the volume of imports was manifest, and great irregularity prevailed in the shipments, the maximum monthly receipts amounting to 21 per cent. of the total, while the minimum was only 1.4 per cent.

The output assumed for Canada is the exportations for 1915, valued at 17.8 cts. per lb. ($3,333,726), but not including manufactured goods valued at $620,562.

The visible supply of crude metal and scrap in the United States in 1915 was practically the same as in 1914, decreased importations being just about compensated for by increased production.

PRODUCTION, IMPORTS AND VISIBLE SUPPLY OF ALUMINIUM IN THE UNITED STATES

	Production.			Imports.			Exports.	Visible Supply. (b)
				Crude.		Mfrs.		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Value.	Value.	Pounds.
1900..	7,150,000	$2,288,000	$0.32	256,559	$44,455	$5,989	$281,821	7,407,000
1901..	7,150,000	2,238,000	0.31	564,803	104,168	5,580	183,579	7,715,000
1902..	7,300,000	2,284,590	0.31	745,217	215,032	3,819	116,052	8,045,000
1903..	7,500,000	2,325,000	0.31	498,655	139,298	4,273	157,187	8,000,000
1904..	7,700,000	2,233,000	0.29	515,416	128,350	478	166,876	8,216,000
1905..	11,350,000	3,632,000	0.32	530,429	106,108	33	290,777	11,880,000
1906..	14,350,000	5,166,000	0.36	770,713	154,292	1,866	364,251	15,121,000
1907..	26,000,000	10,920,000	0.42	872,474	181,351	1,124	304,938	26,872,000
1908..	13,000,000	4,095,000	0.315	465,317	80,268	2,334	330,092	13,465,000
1909..	15,000,000	3,345,000	0.223	5,109,843	745,963	12,878	567,375	20,110,000
1910..	12,000,000	2,736,000	0.228	12,271,277	1,844,830	....	949,215	24,271,000
1911..	(e)28,600,000	5,720,000	0.20	(d)4,173,308	598,272	(d)63,899	1,158,603	32,773,000
1912..	(e)40,000,000	9,200,000	0.23	22,759,937	3,092,889	428,182	1,347,621	62,760,000
1913..	(e)64,900,000	13,600,000	0.21	23,185,755	3,905,977	1,090,229	966,094	88,086,000
1914..	(e)90,000,000	16,740,000	0.186	16,241,340	2,729,383	1,308,036	1,546,510	106,241,000
1915..	(e)99,000,000	31,581,000	0.319	8,534,834	1,511,988	301,863	3,682,117	107,535,000

(a) Not reported. (b) Production plus imports. (d) From July 1 only. (e) Estimated.

Market Prices

The average market price of first quality aluminium varied in New York during 1915 as follows:

	Cents.		Cents.
January	19.00	July	27–29
February	19.00–19.25	August	32–33
March	19.00–19.50	September	31–33
April	19.00–19.25	October	52–55
May	18.75–19.00	November	56–58
June	19.50–19.75	December	56–59

Average price for year, 31.9 cts.

Progress in Various Countries

United States.—The outstanding feature of the industry in 1915 was the passing of the Southern Aluminium Co.'s North Carolina plant into the control of the Aluminum Co. of America. The terms of the transfer are kept private. The French company (L'Aluminium Française) stopped construction operations in August, 1914, and since then has been unable to give the enterprise any attention. This will increase the capacity of the purchasers 70,000 kw., when the hydraulic works and plant are all completed, increasing their annual capacity by 25,000 metric tons (55,000,000 lb.). This capacity was not operative in 1915, and will not be at work before the close of 1916. Extensions of the Maryville plant will be completed by the end of 1915, increasing its capacity 50 per cent. The larger block of power from Cedar Rapids, Can., contracted for at the Massena, N. Y. plant, will be in full use by the middle of 1916. The great St. Lawrence power project, at Long Sault Rapids, which is intended to develop 800,000 hp. for the Aluminum Co. of America, is still hanging fire, the New York State Legislature having given its permission some years ago, but the Canadian government still refuses to allow the river to be dammed. Mr. A. V. Davis, president of the company in question, said in a recent address that "until this deadlock is broken between these people who are conserving the interest of the public, and those who are willing to give the corporations a chance, I do not suppose that this water power can ever be developed." The Aluminum Co. of America has already spent considerable money in acquiring land at this power site, and if it is ever granted permission to develop the power, it is interesting to estimate the corresponding increase in the aluminium business. Eight hundred thousand horsepower, or 600,000 kw., would produce 200,000 metric tons of aluminium per annum, or 440,000,000 lbs. which is two and two-thirds times the present capacity of all the aluminium plants in the world. With a total of about 1,000,000 kw. in operation, this would give an annual production of 325,000 metric tons (715,000,000 lb.), and place aluminium third in importance among metals, being then out-ranked only by copper and iron. It is the writer's opinion that this status will be reached in the aluminium industry by 1925.

Norway.—The British Aluminium Co. have now in operation their plant at Vennesla, near Christianssand, with an annual capacity of 2500 metric tons. A Norwegian company has completed its plant at Eydehaven, near Arendal, and will commence production in 1916. Another Norwegian company with $3,350,000 capital stock, backed by bankers of Christiania and Bergen, will develop and utilize a 60,000 hp.

waterfall in the Hoyan fjord, starting first with 20,000 hp., and a yearly output of 4000 metric tons.

Japan.—It is reported by the *Japan Chronicle* that a company with $500,000 capital stock has been formed to manufacture aluminium at Kachigawa, near Nagoya. Two out of the three largest manufacturers of aluminium articles in Japan have been forced to stop work because of the scarcity of aluminium and its high price, and this condition has led to the move to make their own metal. Bauxite ore, is, however, lacking in Japan, and it is doubtful whether "a rich deposit of potter's clay in the neighborhood of Kachigawa" will satisfactorily supply the raw material for the industry.

Metallurgy and Uses

Practically no new information has been given out, in 1915, on the methods of producing aluminium. It is certain, however, that nothing revolutionary has transpired; steady improvement in small details is all that has happened, and since these are the only essential features in which the practice of the different companies varies, preserving them secret is the universal policy of the industry.

Melting Scrap.—Considerable attention has been given however, to the problem of retrieving scrap aluminium. It seems uncanny, at first sight, to think of aluminium articles finding their way into the ash heap and thence, eventually into the junk dealer's hands, but yet it is the fact that worn-out cooking utensils are appearing for the first time in history as junk and scrap, quite valuable when the new metal sells for 50 cts. per lb. Added to this is the wastage from factories, such as filings, borings, turnings, planings, punchings, and miscellaneous scrap. Several thousand tons of such "secondary" aluminium appears on the market annually, to be re-melted and sold at a lower price than new metal. It is frequently impure from admixture of other metals and light aluminium alloys. It will always pay the factories to carefully segregate the scrap of pure metal from that of alloys, and thus command a higher price for the material. The problem of melting such scrap has been the subject of several articles in the technical journals.

H. W. Gillett read a paper before the American Institute of Metals in October, 1915, on "Melting Aluminium Chips." The paper, amplified, is to appear as a bulletin of the Bureau of Mines. In this paper it is stated that the ordinary metal melter, putting such material into a crucible, gets only 50 to 70 per cent. of its weight as good metal, and loses 30 to 50 per cent. as dross. Such borings have a superficial layer of oxide, grease and dirt upon them, which prevents the globules of melted metal from running together. With constant stirring those films may be broken up, and perhaps 70 per cent. of metal obtained; if the borings were cut wet with a salt solution on the tool, and the salt allowed to dry on them, a yield of 50 per cent. can hardly be exceeded. Experiments were made with fluxes such as: (*a*) zinc chloride and salammoniac and (*b*) 85 parts common salt to 15 parts fluorspar, in a small gas-fired reverberatory, in crucibles and in an electric furnace, with the following percentage yields:

	Reverberatory.	Crucibles.	Electric Furnace.
Salammoniac, stirred	50–60	65–70	70
Salt and fluorspar flux	80–90	75–85	85
Chips briquetted, same flux	....	90	....

Aluminium Powder.—Under the title "Aluminium Dust," G. H. Clevenger describes[1] the manufacture and properties of this interesting material. Two analyses of good grades are given:

	A.	B.
Aluminium	91.20	92.50
Aluminium oxide	5.80	5.72
Silica	1.30	} 1.78
Silicon	0.40	
Carbon	0.23	
Moisture	1.07	
Nitrogen	Trace	

The poorer grades are frequently adulterated with powders of zinc or tin, also with mica. The price averages twice that of ingot metal. The manufacture starts with imperfect foil, which has been damaged in manufacture. This is comminuted in stamp mills into which is fed wax or stearine, to prevent the pieces welding or sticking together. The product is bolted, winnowed like bran, and finally polished in a special machine. Another method is to force gas or air into melted metal while it is setting, with vigorous mechanical stirring. The grains are then powdered in stamp or ball mills. Small explosions are frequent in the grinding mills, which are in an isolated fire-proof building; electrical discharges probably ignite the dust-air mixture. Besides being used in the Goldschmidt process of reducing other metallic oxides to carbon-free metal (manganese, chromium, etc.) and as "bronze powder" in aluminium paint, it is being used extensively in explosives. The latter use was proposed by Escales, in Munich, in 1899, and in 1900 von Dahmen patented an explosive containing powder of aluminium mixed with an oxidizing agent. Mixed with ammonium nitrate it is

[1] *Min. Sci. Press*, Jan. 22, 1916.

known as "ammonal," used in mining and in high explosive shells. Its combustion is as follows:

$$3NH_4NO_3 + 2Al = Al_2O_3 + 6H_2O + 3N_2$$

It is sometimes added to other explosives, *e.g.*, a modern powder containing:

	Parts.
Di- or tri-nitrotoluene	1905
Ammonium nitrate	45
Aluminium powder	22

Undoubtedly a large tonnage of aluminium is at present going into such uses.

Electrical Conductors.—A combination cable has come into extensive use, consisting of aluminium wires twisted tightly upon a galvanized steel core. Taking a hard-drawn steel wire of 160,000 lb. per sq. in. (112 kg./sq. mm.) tensile strength and 130,000 lb. (91 kg.) elastic limit, and twisting upon it six aluminium wires of equal diameter, the combination has 80 per cent. of the weight of a copper cable of equal conductance and is 57 per cent. stronger. With about equal cost for cable per mile, it is possible to make so much longer spans that there are great savings in towers, insulators, cost of erection and leakage.

E. V. Pannell[1] discusses this subject at length. Of special interest in this paper are the curves of strength of aluminium wire showing its variation with diameter, as follows:

Diameter of Wire.		Elastic Limit.		Tensile Strength.	
Inches.	Mm.	Lb./sq. in.	Kg./sq. mm.	Lb./sq. in.	Kg./sq. mm.
Commercial, hard-drawn					
0.04	1	....	....	31,400	22.0
0.08	2	....	....	27,600	19.3
0.12	3	....	....	24,800	17.4
0.16	4	....	....	23,400	16.4
0.20	5	....	....	22,000	15.4
Spec. grade, hard-drawn					
0.04	1	28,700	20.1	38,000	25.9
0.08	2	22,000	15.4	32,000	22.4
0.12	3	15,700	11.0	29,000	20.3
0.16	4	11,000	7.7	27,500	19.2
0.20	5	7,600	5.3	26,700	18.7

Mr. Pannell gives a table of 30 long-distance transmission lines in North America using aluminium conductors. The lengths are up to 275 miles, voltage up to 150,000, spans usually 500 to 600 ft., maximum 2350 ft., and weight of aluminium used 12,200 tons. He predicts that the composite aluminium-steel cable, already used in some of the largest and most recent systems, will probably come into very general use.

[1] Amer. Inst. of Metals, Oct., 1915.

It is interesting to note, as a temporary phase of the disturbances caused by the war, that a number of aluminium transmission lines were taken down in the latter part of 1915 and replaced by copper at 22 cts. ingot price. It is safe to say that such an opportunity to "turn an honest penny" will never occur again, for in the near future aluminium will sell permanently at less than the price of copper, and be nearly half its cost for electrical conductor purposes.

Welding.—E. V. Pannell discussed this subject before the American Institute of Metals, in October, 1915. He recommends the oxy-acetylene flame as preferable to the oxy-hydrogen, for this work, in the hands of a skilled workman. He specifies the following percentage compositions of fluxing mixtures used in this art:

	Per Cent.					
Sodium chloride	30	......	12.5	16	17	6.5
Potassium chloride	45	33	62.5	79	83	56.0
Lithium chloride	15	33	21.0	......	......	23.5
Potassium fluoride	7	......	......	......	......	......
Sodium bi-sulphate	3	......	......	......	......	......
Sodium fluoride	......	33	......	......	......	......
Potassium bi-sulphate	......	......	4.0	......	......	......
Potassium sulphate	......	......	......	5	......	......
Sodium sulphate	......	......	......	......	......	4.0
Cryolite	......	......	......	......	......	10.0

The melting points of these mixtures are all lower than that of aluminium, so that they melt and flux away the surface layer of oxide before the metal melts. The powders are moistened with alcohol before using, to keep them from being blown away by the flame. It is also possible to make the feeding stick of metal which is melted in the joint hollow, and put the flux mixture inside it. The feeding sticks are either pure metal or an alloy containing a small amount of zinc and magnesium.

Die Castings.—Charles Pack[1] emphasizes the fact that die casting of aluminium and aluminium alloys is essentially an American achievement, giving the credit to the patented process of H. H. Doehler, which he states to be used to the extent of 75 tons a month (900 tons a year) in the automobile industry alone. The alloy used is aluminium hardened by copper; it is found best to omit zinc, tin and cadmium, since these cause the castings to warp and crack in time. The dies used do not last very long; about 5000 castings to one die is the average life.

Alloys

At least one-quarter of all the aluminium made is used up in light, stiff alloys, particularly in the automobile industry. The zinc, copper, and magnesium alloys are the favorites and considerable new literature has appeared describing them and their uses.

[1] Amer. Inst. of Metals, Oct. 1, 1915.

Zinc-aluminium Alloys.—Dr. H. Schirmeister[1] describes the mechanical properties of these alloys up to 31 per cent. of zinc. All these alloys can be rolled. The following alloys were rolled slowly at 350° to 400° C.

Zinc, Per Cent.	Tensile Strength.		Elongation, Per Cent.	Brinell Hardness.
	Kg./sq. mm.	Lb./sq. in.		
0.0	10.5	15,000	34	29
5.7	13.2	18,900	26	37
12.7	20.4	29,100	33	50
18.5	28.8	41,100	20	77
25.3	37.6	53,700	15	124
31.0	34.3	49,000	14	150(?)

Reviewing these figures, the tensile strength rises slowly to about 8 per cent. zinc, then fast and regularly to 25–27 per cent., and afterward falls off slightly; the elongation sinks to a minimum at 6 per cent. zinc, then rises to a maximum at about 13 per cent., then falls regularly; the hardness increases slowly to about 10 per cent. zinc, then increases fast and regularly.

J. W. Richards gives the mechanical properties of some zinc alloys containing copper and manganese[2] as follows:

Composition.	Tensile Strength.		Elastic Limit.		Elongation, Per Cent.
	Kg./sq. mm.	Lb./sq. in.	Kg./sq. mm.	Lb./sq. in.	
30.0 per cent. zinc 1.5 per cent. copper } cast.....	29.8	42,500	17.5	25,000	0.8
15.0 per cent. zinc 3.0 per cent. copper 0.5 per cent. manganese } cast.....	20.6	29,415	11.2	16,000	0.5

These alloys are of closer grain and finer texture than the plain zinc alloys, and are very largely used for motor-casing castings for automobiles.

Copper-aluminium Alloys.—Dr. H. Schirmeister (*l.c.*) gives the following mechanical properties of these alloys rolled slowly at 400°–450° C.:

Copper, Per Cent.	Tensile Strength.		Elongation, Per Cent.	Brinell Hardness.
	Kg./sq. mm.	Lb./sq. in.		
0.0	10.5	15,000	34	29
1.0	15.4	22,000	26	41
2.1	17.1	24,400	23	46
3.5	18.0	25,700	22	48
5.1	17.8	25,400	21	49
7.1	18.0	25,700	21	49
8.9	18.7	26,700	19	52
11.0	19.5	27,900	16	55(?)

[1] *Stahl u. Eisen*, June 24, 1915.
[2] Internat. Engr. Cong., San Francisco, 1915.

These figures show a rapid increase in strength and hardness and brittleness up to about 4 per cent. copper, then nearly stationary qualities to 7 per cent. copper.

J. W. Richards (*l.c.*) states that 2 to 3 per cent. copper alloy casts and works nicely, and is often used; he gives the following mechanical properties of 6 per cent. copper alloy and of a composite 3 per cent. alloy.

Composition.		Tensile Strength.		Elastic Limit.		Elongation, Per Cent.
		Kg./sq. mm.	Lb./sq. in.	Kg./sq. mm.	Lb./sq. in.	
6 per cent. copper	rolled hard.....	24.5	35,000	....	....	3.5
	annealed.......	17.5	25,000	....	....	15.5
	cast...........	15.0	21,500	8.4	12,000	1.5
2.0 per cent. copper, 0.5 per cent. nickel, 0.5 per cent. zinc	cast..........	15.4	22,000	....	....	....
	annealed......	28.0	40,000	....	....	4.0

Magnesium-aluminium Alloys.—These simple binary alloys are known as "Magnalium." Schirmeister (*l.c.*) gives their properties up to 6 per cent. magnesium, rolled slowly at 450° C. as follows:

Magnesium, Per Cent.	Tensile Strength.		Elongation, Per Cent.	Brinell Hardness.
	Kg./sq. mm.	Lb./sq. in.		
0.0	10.5	15,000	34	29
0.3	10.9	15,600	34	33
0.6	11.4	16,300	33	33
1.2	11.2	16,000	33	33
1.6	11.4	16,300	33	34
2.6	15.3	21,900	25	42
4.0	21.1	30,100	22	54
6.0	29.4	42,000	21	69

These tests show that above 1.6 per cent. magnesium there is a remarkably quick increase in tensile strength and hardness, with lowering of ductility. From 4 per cent. magnesium the fracture is very finely granular, and the shrinkage rapidly lessens. The 6 per cent. alloy is a very desirable and useful one. They are lighter than aluminium and easy to work.

"Duralumin" containing 0.5 per cent. magnesium, 0.5–0.8 per cent. manganese, and 3.5–5.5 per cent. copper is said to show 50,000 to 60,000 lb. per sq. in. (35–42 kg. per sq. mm.) tensile strength, with 8 per cent. elongation.

The reclaiming of "Magnalium" from turnings has become an important question, and was discussed by J. Coulson before the American

Institute of Metals, October, 1915. The alloys run from 5 to 10 per cent. of magnesium, and oxidize rapidly if one attempts to melt their scrap down in the ordinary manner. If cryolite is melted in a graphite crucible and the turnings pushed under the surface, the oxide is dissolved from their surface and the metal runs together well, the yield being 60 to 90 per cent. of the weight of the turnings. The crucibles are, however, strongly attacked, and iron pots can not be used. Avoiding cryolite, the turnings are first washed in benzine, to remove grease, then fed into a crucible heated to 900° C. in which is some melted magnalium. The whole is puddled vigorously, and then 1 per cent. of metallic calcium or 0.5 per cent. of calcium-aluminium-silicon alloy added as a de-oxidizer. The metal poured is restored to its original physical properties, and the loss on a 200-lb. charge is only about 1 per cent.

Vanadium-aluminium Alloys.—W. W. Clark[1] describes the production of these alloys for use in adding vanadium to bronze and brass. By igniting a mixture of vanadic oxide and powdered aluminium on the surface of melted aluminium in a graphite crucible, almost all the oxide was reduced. Also, by electrolyzing a melted mixture of cryolite, alumina, fluorspar and vanadic oxide with melted aluminium as cathode, alloys are obtained, but not so uniform in composition as by the crucible method. Some of the alloys thus made were as follows:

Vanadium, Per Cent.	Aluminium, Per Cent.	Silicon, Per Cent.	Carbon, Per Cent.	Iron, Per Cent.	Melting Point, C°.
10.62	88.43	0.46	0.11	0.04	715
13.93	85.27	0.54	0.06	0.08	742
16.24	83.11	0.42	0.08	0.05	884
21.12	77.54	1.02	0.14	0.12	990

Some of these alloys, added to brass to the amount of 4 per cent., introducing therefore about 0.45 per cent. vanadium and 3.5 per cent., gave increased tensile strength and elongation, but not sufficient to warrant the expense.

Aluminium Bronze Alloys.—W. M. Corse,[1] calls attention to the fact that the 10 per cent. bronze (10 per cent. Al, 90 per cent. Cu) has properties very similar to a Swedish Bessemer steel of 0.35 per cent. carbon, including the property of being hardened by heat treatment. By heating to various temperatures up to 800° C. and quenching, hardness of 100 to 260 on the Brinell scale can be obtained. Machinery bearings treated in this manner have given excellent results on high speeds, up to 20,000 r.p.m. By incorporating some titanium in the bronze

[1] Amer. Inst. of Metals, Oct., 1915.

as a scavenger (amount not specified, probably a few tenths per cent.) and giving the alloy special heat treatment, the following mechanical properties have been obtained:

Elastic limit	39,300–56,700 lb./sq. in. = 27.5–39.7 kg./sq. mm.
Tensile strength	91,200–96,700 lb./sq. in. = 63.8–67.7 kg./sq. mm.
Elongation in 2 in.	5.5–14.0 per cent.
Reduction of area	9.1–18.5 per cent.
Brinell hardness	140 – 158

This special treated aluminium bronze was tested against manganese bronze, as follows:

	Al Bronze.	Mn Bronze.
White-Souther test, reversals	15,000,000	1,000,000
Landgraf-Turner test, blows	4,500	500

Bauxite[1]

The production of bauxite in the United States in 1915 was 297,041 long tons, valued at $1,514,834, an increase of 77,723 tons, or 35 per cent., in quantity and of $445,640, or 41 per cent., in value, as compared with the production in 1914.

The States which produced bauxite were, as usual, Alabama, Arkansas, Georgia, and Tennessee. Arkansas was the largest producer owing to the extensive operations of the American Bauxite Co. in Saline County. The Globe Bauxite Co. operated at Chemical Spur, Saline County, and the Republic Mining & Manufacturing Co. near Little Rock, Pulaski County. The National Bauxite Co. has also leased bauxite lands near Little Rock.

The average price of bauxite per long ton at the mines was, in 1911, $4.82; in 1912, $4.81; in 1913, $4.75; in 1914, $4.87; and in 1915, $5.10.

PRODUCTION OF BAUXITE IN THE UNITED STATES BY STATES
(In tons of 2240 lb.)

State.	1905.	1906.	1907. (a).	1908. (a).	1909. (a).	1910. (a).	1911. (a)	1912. (a).	1913. (a).	1914.
Alabama... Georgia....	17,094	27,131	97,776	14,464	22,227	33,096	30,170	19,587 14,173	27,409	18,547
Arkansas...	30,897	51,200	(b)	(b)37,703	(b)106,814	(b)115,836	125,448	(b)126,105	(b)182,832	(b)200,771
Total...	47,991	78,331	97,776	52,167	129,101	148,932	155,618	159,865	210,241	219,318

(a) Statistics of the U. S. Geol. Surv. (b) Production of Tennessee included.

[1] Abstracted from U. S. Geol. Surv. reports, with some additions.

CONSUMPTION OF BAUXITE IN THE UNITED STATES

Year.	Production.			Imports.		Consumption.	
	Long Tons.	Value.	Per Ton.	Long Tons.	Value.	Long Tons.	Value.
1906....	78,331	$352,490	$4.50	17,809	$63,221	96,140	$415,716
1907....	(a) 97,776	480,330	4.91	25,066	93,208	122,842	513,538
1908....	(a) 52,167	263,968	5.05	21,679	87,823	73,846	351,791
1909....	(a) 129,101	679,447	5.27	18,689	83,956	147,789	163,403
1910....	149,679	778,203	5.33	15,720	65,743	164,601	782,001
1911....	155,618	750,649	4.87	43,222	164,301	198,840	914,950
1912....	160,124	900,620	5.00	26,214	95,431	186,079	864,363
1913....	210,241	997,698	4.75	21,456	85,746	231,697	1,083,444
1914....	219,318	1,069,194	4.87	24,844	96,500	244,162	1,165,694
1915....	297,041	1,514,834	5.10	1	393	297,042	1,515,227

(a) Statistics of the U. S. Geol. Surv. (e) Estimated.

WORLD'S PRODUCTION OF BAUXITE, 1910–1913, IN LONG TONS

Country.	1911.	1912.	1913.	1914.	1915.
United States ...	155,617	159,865	210,241	219,318	297,041
France..........	250,818	254,760	304,314	(a)	(a)
United Kingdom	6,007	5,790	8,282	8,286	11,723
Italy	5,600	6,596	6,841	3,844	(a)
India	12	950	1,184	514	
Total	418,055	427,961	530,862	....	....

(a) Statistics not available.

Bauxite in the United States

Alabama.—The Republic Mining & Manufacturing Co. was the only one that operated in Alabama in 1914. The company worked near Rock Run, Cherokee County, in the eastern part of the State.

Arkansas.—The State of Arkansas has produced for several years more than 80 per cent. of the bauxite mined in this country. The reason for this is that the American Bauxite Co., the principal producer in the United States, has concentrated its work in this State. The greater part of the production comes from what is known as the Bauxite district, also known as the Bryant district, which lies about 22 miles southwest of the city of Little Rock and covers an area of about 12 square miles in Bryant Township, Saline County. Bauxite, the town from which the material is shipped, is located on the Chicago, Rock Island & Pacific Railway 5 miles east of Benton, the county seat of Saline County. The mines are located on the Bauxite & Northern Railway, a spur built from Bauxite Junction, on the St. Louis, Iron Mountain & Southern Railway system. This spur crosses the Rock Island tracks at Bauxite station.

The second and less important district is known as the Fourche Mountain district, which is located immediately south of the city limits of Little Rock, in Pulaski County, and which embraces an area somewhat larger than the Bauxite district. The two areas are about 15 miles apart.

During 1914 three other companies besides the American Bauxite Co. operated in Arkansas. The National Bauxite Co. began work at the beginning of the year on a property located 7 miles south of Little Rock on the Rock Island Railway. This particular property had never been worked before. The Globe Bauxite Co. worked at Chemical Spur, Saline County, and the Republic Mining & Manufacturing Co. operated near Little Rock, in Pulaski County.

Georgia.—The Republic Mining & Manufacturing Co. reported a small production from the district near Rome, Floyd County, in 1914 For many years this company has mined bauxite north of Rome in the vicinity of Hermitage. The main operations of the company in this State in 1914 were at McIntyre, Wilkinson County, and east of Andersonville, Sumter County, in the central Georgia district. The National Bauxite Co. also worked in the McIntyre district. The Cherokee Mining Co. mined ore near Hall's station, Linwood post office, Bartow County.

Bauxite was first discovered in central Georgia in 1907 by Otto Veatch while making a study of the white clays of the Cretaceous horizon. Following the announcement of the original discovery, which was in Wilkinson County, a number of similar occurrences were soon reported. The first shipment of ore from this field was made by the National Bauxite Co. in the summer of 1910, and the production has increased annually since that time.

More recently bauxite has been discovered near Andersonville, in Sumter County, and near Oglethorpe, in Macon and Schley Counties. This new area is about 70 miles southeast of the Wilkinson County area, and the developments are very promising. The occurrence here is the same as in Wilkinson County, but the ore appears to be of a somewhat better grade.

The bauxite in this area is for the most part made up of pisolitic concretions, though in places it is massive, halloycitic and almost free of concretions. The pisolites may vary in size from smaller than a pea to an inch or more in diameter. The bauxite varies in color from a cream white, which is the purest variety, through buff and pink to a bright red. The impurest varieties, or red ores, contain much iron stain, and free silica in the form of sand.

The method of mining bauxite in this field is not unlike that which has been commonly practised at the white clay mine in the same district for many years. It is the simple operation of stripping the beds of their overburden and winning the ore with pick and shovel. As the bauxite is sometimes hard, a small amount of shooting with black powder is necessary in order to loosen the ore. After mining the ore is conveyed to the usual type of rotary kiln dryer, from which after drying it is hauled in wagons to the railroad. Native negro labor is commonly employed, though a few white men are used around the dryers.

Both the National Bauxite Co. and the Republic Mining & Mfg. Co. have operated mines in this district, but at present the National is not a producer. The Republic is operating one mine near McIntyre, in Wilkinson County, and another near Andersonville, in Sumter County.[1]

Tennessee.—Bauxite was mined in 1914 at only one locality in the vicinity of Chattanooga, namely, near Sherman Heights, on the southeastern slope of Missionary Ridge. The work was done by the National Bauxite Co. Work at the Tunnel deposits which were described in this report for 1913 was not continued in 1914.

Uses of Bauxite

The chief uses of bauxite are as follows: (1) As raw material in the production of metallic aluminium; (2) in the manufacture of aluminium salts; (3) in the manufacture of bauxite bricks; (4) in the manufacture of alundum, aloxite, etc., (fused alumina) for use as an abrasive. The use of bauxite in the manufacture of calcium aluminate to give a quick set to plaster compositions should be added, as well as the extended use which alundum is finding in the refractory industries.

1. The use of bauxite in the production of metallic aluminium is by far the most important of those enumerated. A large part of the output of Arkansas is used for metallic aluminium, and the figures of production from this State have shown phenomenal growth during recent years. A large part of the imported French bauxite is also used in the manufacture of metallic aluminium.

2. Only the purer bauxite is used in the manufacture of chemicals, such as alum, aluminium sulphate, and aluminium salts in general. Freedom from oxide of iron is essential in the material to be used in the chemical manufactures.

3. Bauxite is used in the manufacture of bauxite bricks for furnace linings. The purer the bauxite used, the more refractory is the resulting product; and, moreover, the addition of bauxite to refractory clays not only increases their content of alumina but also their refractoriness. Attention should be called to the results of certain tests on the melting point of alumina, bauxite, and bauxite brick made at the United States Bureau of Standards. According to these tests pure alumina was found to melt at 2050° C., but none of the bauxite

[1] J. H. Watkins, *Min. Eng. World*, June 12, 1915.

brick examined approached this melting point. A sample of bauxite was tested and found to melt completely at 1820° C., the centers of the nodules melting at 1790°. A sample of bauxite clay melted at 1795° C. In one sample of bauxite the melting point, after previous heating for 6 hr., varied from 1730° C. to 1740°C .; without previous heating, it varied from 1740° C. to 1745° C. In eight samples of bauxite brick the melting point varied, without previous heating, from 1565° C. to 1785° C.

4. Bauxite is used on a large scale at Niagara Falls in the manufacture of the artificial abrasives, alundum, aloxite, etc. These are made in the electric furnace by fusing calcined bauxite. The product is a crystalline aluminium oxide and virtually amounts to a form of artificial corundum. The quality of the product is under complete control and can be duplicated with ease for use in the various abrasive processes, a factor of great importance in any successful abrasive industry.

5. Last should be mentioned the application of bauxite in the manufacture of calcium aluminate to give a quick set to plasters. For a full description of the use of bauxite in calcium aluminate the reader is referred to *Mineral Resources* for 1911.

Bauxite in Foreign Countries

British Guiana.[1]—Prospecting for bauxite was carried out in the upper Demarara and deposits located. Quarrying titles were applied for on the Colony lands at Christianburg and Wismar, and Crown lands at Three Friends. An American company acquired from private individuals 13,000 acres on the Demarara River, in some cases securing the free hold, and in others only the mining rights.

Dutch Guiana.—A discovery of bauxite was made in September, 1914, in the hills bordering the Saramacca River. Since the mineral can be loaded directly into the ship at the river bank, the operation of the deposit should be easy, the climate offering the principal drawback. The quality of the material is good and it is understood that the deposit has been acquired by American interests.

India.[2]—Some years ago it was discovered that many of the lateritic deposits of India are highly aluminous, such aluminous varieties being identical with the substance known as bauxite. Field work carried out since 1903 by the officers of the Geological Survey has revealed the existence of extensive deposits of this mineral substance in various parts of India, and chemical investigation in the Geological Survey Laboratory and at the Imperial Institute has shown that certain of the Indian baux-

[1] *Eng. Min. Jour.*, Apr. 22, 1916. From the Annual Report of the Commissioner of Lands and Mines for the colony.
[2] *Rec. Geol. Surv. Ind.*, **46**, 228 (1915).

ites compare very favorably with the Irish, French and American bauxites placed on the English market.

The richest areas yet discovered in India are the Baihir plateau in the Balaghat district and the neighborhood of Katni in the Jubbulpore district, both in the Central Provinces. But valuable ores have also been found in Kalahandi State and Chota Nagpur, Bihar and Orissa, in Bhopal and Rewah States, Central India, in the Satara district, Bombay, and in various parts of the Madras Presidency. The bauxites to which the most attention has been up to the present devoted are those of Balaghat and Jubbulpore. Eight analyses of specimens and samples of the Balaghat bauxites have given results ranging between the following limits:

	Per Cent.
Alumina, Al_2O_3	51.62 to 58.83
Ferric oxide, Fe_2O_3	2.70 to 10.58
Titanic oxide, TiO_2	6.22 to 13.76
Silica, SiO_2	0.05 to 2.65
Combined water, H_2O	22.76 to 30.72
Moisture	0.40 to 1.14

corresponding to 71.2 to 80.8 per cent. of Al_2O_3 after calcination.

Two Katni bauxites give the following analyses:

	No. 1.	No. 2.
Al_2O_3	65.48	52.67
Fe_2O_3	3.77	7.04
TiO_2	11.61	7.51
SiO_2	0.38	1.26
H_2O	19.38	29.83

From these figures it will be seen that the Balaghat and Jubbulpore bauxites are of very high grade. There seems also to be little doubt that large quantities of the mineral are available, and the commercial feasibility of making use of these deposits has consequently been under investigation for some years. There are three ways in which the Indian bauxites might be developed:

1. Simple export of the raw or calcined material to Europe or America.

2. Manufacture of pure alumina locally by extraction with alkali, and export of the pure oxide to European or American aluminium works.

3. Manufacture of the metal in India.

The first proposal is impracticable on account of the low prices of raw bauxite at European ports, while the third would involve a heavy capital outlay under untried conditions, and an elaborate preliminary investigation before power works could be erected. The second proposal involves much smaller risks, and it has been found on investigation that there are no technical difficulties in the way of manufacturing alumina from Indian bauxites. Several concessions have been taken out for working the bauxites of the Central Provinces, in the practical investigation of which considerable progress has been made.

The occurrence of aluminous laterite at Tikari near Katni, Jubbulpore district, was first noted by Mr. F. R. Kallel in 1883. Early in 1905, after the Geological Survey had drawn attention to the identity of aluminous laterites with bauxite, Mr. P. C. Dutt of Jubbulpore secured an exploring license over this area, and later prospecting licenses were taken out by Mr. Dutt and a syndicate formed by him called the Bombay Mining and Prospecting Syndicate, with Messrs. C. MacDonald & Co., of Bombay, as managing agents. The objects of this syndicate were varied, including the manufacture of hydrated alumina, alum, and aluminium; of cement and lime; and of pottery, fire-bricks, etc., materials for all these purposes being found within the bauxite concessions.

In August, 1912, the Katni Cement and Industrial Co., Ltd., was floated to acquire the Katni properties of the above syndicate, including the bauxite deposits. The cement works commenced operations in December, 1914, with satisfactory results. Works have also been erected at Katni for the manufacture of tiles, piping, fire-bricks, and bauxite bricks.

Meanwhile Mr. P. C. Dutt has acquired other bauxite deposits near Katni, and also near Dundi Station, East Indian Railway, also in the Jubbulpore district, and has continued his efforts to enlist the help of capital to work both his Jubbulpore and Balaghat bauxite deposits for the manufacture of alumina and ultimately of aluminium.

Italy.—The production of bauxite in Italy in 1914 was 3906 metric tons, compared with 6952 tons in 1913. Of this quantity, 3820 tons, along with 900 tons of French bauxite, was treated by the caustic soda process by the "Societá per la fabbricazione dell'aluminio" at Bussi, producing 1848 tons of alumina, which, with 275 tons of other alumina produced 937 tons of metallic aluminium, an increase of 63 tons over the production of 1913.

In addition to bauxite there was produced in 1914, alunite to the amount of 3700 metric tons, as compared with 5976 tons in 1913.

Aluminium Salts

The following table gives the domestic production, the imports, and the value of aluminium salts in the United States from 1910 to 1914, inclusive, according to the U. S. Geological Survey.

PRODUCTION AND IMPORTS OF ALUMINIUM SALTS
(In short tons)

Years.	Production.						Imports. (a)	
	Alum.			Aluminum Sulphate.			Quantity.	Value.
	Quantity.	Value.	Per ton.	Quantity.	Value.	Per ton.		
1910........	9,090	$300,763	$33.09	126,792	$2,447,552	$19.30	2,127	$53,671
1911........	10,468	329,686	31.49	134,077	2,743,336	20.46	2,283	56,833
1912........	9,246	293,995	31.80	150,427	2,909,495	19.34	3,342	84,606
1913........	9,605	312,822	32.57	157,749	2,977,708	18.88	2,702	66,549
1914........	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	73,028

(a) Includes alumina, aluminium hydrate, or refined bauxite, alum, alum cake, aluminium sulphate, aluminous cake, and alum in crystals or ground.

Australia.—Thirty miles north of Port Stephens, N. S. W., is a small village called Bullahdelah, situated close to what is known as the Alum Mountain. This mountain is composed entirely of alunite, and it is the only known deposit in Australia.

The stone yields on an average 80 per cent. of alum. According to the statistics for the Mining Industry of New South Wales, the output of alum from the years 1856 to 1908 was valued at $450,000 and for 1908 to the end of 1913, $190,000. Since the year 1908 about 1200 tons of the rock have been taken out annually and shipped to England for treatment, where the alum is extracted much more cheaply than is possible here. The Australian Alum Co. (Ltd.) is the operating company, with head offices at 109 Pitt Street, Sydney, and the works are at Bullahdelah, New South Wales.[1]

Italy.—During 1914 alunite amounting to 2400 tons was exported to France, and 1862 tons was used in the manufacture of alum and aluminium sulphate. The production of alum during 1914 amounted to 1307 tons, and of aluminium sulphate 3229 tons. In addition to the production, imports of aluminium salts for the year amounted to 2602 tons, while 1432 tons was exported.

India.[2]—The separation of sulphate of alumina from decomposed pyritous shales, and the preparation of the double sulphate of alumina and potash, by the introduction of niter or wood-ashes, was formerly an important industry in a few places, and, on a smaller scale, was practised at numerous places in India. But the importation of cheap alum, principally from the United Kingdom, and its wide distribution by the gradually extending system of railways, have now nearly killed the native industry.

[1] *Comm. Rept.*, Aug. 25, 1915.
[2] *Rec. Geol. Surv.*, **46**, 226 (1915).

CONSUMPTION OF FOREIGN ALUMINOUS SULPHATES (INCLUDING ALUM) IN INDIA

Year.	Tons.
1908–09	3369
1909–10	3399
1910–11	3451
1911–12	2599
1912–13	4919
1913–14	4352

The only portion of India for which returns have hitherto been available is the Mianwali district, Punjab, where, during the 5 years under review, there was an average annual production of 302 tons. The raw material is a pyritous shale of Eocene age found at Kalabagh, Kotki, and other localities in the Isakhel tahsil. The average sulphur-content in the workable patches of these shales is, according to Mr. N. D. Daru, 9.5 per cent. After roasting, the shale is lixiviated and concentrated. A mixture of crude chlorides, nitrates, and sulphates of sodium (chiefly) and potassium is then added, the alum crystallized out, and then fused in its water of crystallization and allowed to recrystallize. The product is mainly soda-alum, and is used at Delhi, Hissar, Sirsa, and other centers of the tanning and dyeing industries.

ANTIMONY

By Thomas Forrester Wettstein

"Crude Antimony" is a liquated sulphide of antimony. "Needle Antimony" is also a liquated sulphide of antimony. "Regulus Antimony" is the antimony of commerce; it may contain also sulphur and some impurities. "Star Antimony" is the best brand and is guaranteed usually to contain at least 99.6 per cent. antimony.

The following are analyses of the different brands of antimony made by (A) The American Sheet & Tin Plate Co., and (D) The National Lead Co.[1]

	Cookson's.		Hallett's.		Japanese.		Chinese.	
	A	D	A	D	A	D	A	D
Pb	0.041	0.102	0.669	0.718	0.443	0.424	0.018	0.029
Sn	0.035	Trace	0.175	0.012	0.175	0.012	0.035	None
As	Trace	0.092	Trace	0.210	0.008	0.095	0.017	0.090
Bi	....	None	....	None	....	None	....	None
Cu	0.040	0.046	0.038	0.046	0.034	0.043	0.008	0.012
Cd	....	None	....	None	....	None	....	None
Fe	0.010	0.004	0.014	0.007	0.015	0.007	0.007	0.004
Zn	Trace	0.034	Trace	0.023	Trace	0.023	Trace	0.027
Ni + Co	....	0.028	....	None	....	None	....	Trace
S	....	0.086	....	0.128	....	0.201	....	0.078

The following is an analysis of two samples of refined antimony by Pautrat.[2]

	No. 1.	No. 2.
Pb	Trace	0.081
As	0.265	Trace
Fe	0.190	0.070
SO_2	Trace	0.008
Sb	99.450	99.690

The following analyses are results of work by the Bureau of Standards at Washington.[3]

	Cookson's.	French, H. H.	Chinese.
Cu	Possible trace	Not detected	Not detected
Pb	0.06 per cent.	Trace	13 per cent.
Sn	Not detected	Not detected	Not detected
Zn	Trace	0.09 per cent.	0.1 per cent.
Fe	Not detected	Not detected	Not detected
As	Possible trace	Possible trace	Not detected
Bi	Not detected	Not detected	Not detected
Ni + Co	Not detected	Not detected	Not detected

[1] Amer. Inst. Metals, 1915.
[2] *Rev. de Chemie Industrielle*, Mar., 1907.
[3] *Amer. Metal Market Report.*

The antimony market is confined to a few smelters and speculating agents, and the price is a matter of private contract in most cases.

Antimonial lead ores carry from 3 to 10 per cent. antimony and are usually sold at the price of lead at the mine, and also sometimes by dealers on consideration that they receive the resulting hard lead at an advantage on the market price of lead.

Antimony in 1915

The leading brand of antimony has always been considered to be "Cookson's" but in May, 1915, soon after the British Government placed an embargo on antimony, this brand was quoted at 40 cts. per lb. In a few days, however, quotations on Cookson's ceased, and shortly after this Hallett's and Hungarian quotations also ceased—leaving the entire market to Chinese brands, which were quoted in the latter part of June at 37 to 37½ cts. per lb.

These conditions caused the American users to prospect this and neighboring countries for antimony ores free from arsenic, lead, zinc and copper. A number of deposits hitherto unprofitable are now being worked. Mexico, Alaska, California and Nevada have all contributed to the local supply and several smelters which formerly refined antimony ores have resumed operations. The Chapman Smelting Co., of San Francisco, again started smelting antimony ores which they obtained at Bernice, Nev., and brought ores from other points in the Western States, Alaska and Canada. The Merchant's Finance Co. built an antimony smelter at Industrial Harbor, Los Angeles, and are smelting California, Nevada and Alaskan ores. The Antimony Smelting and Refining Co., of Seattle, have lately opened a plant, which will make antimony oxide and smelt and refine metal.

In 1915, over 800 tons of stibnite ore were mined in Alaska, of which nearly 700 tons came from the Fairbanks district, and the remainder from Seward Peninsula. The probable value of the total shipments made from Alaska in that year approximates $70,000. The Fairbanks district comprises four antimony properties which have been operated lately: The Scrafford, in the Treasure Creek basin; the Stibnite in the Eva Creek basin; the Gilmer in the Vault Creek basin, and the Chattan Creek Mine; all these operations were on a small scale, most of the ore being hand-sorted. The ore was hauled to the railway by wagons, whence it was taken to Fairbanks and thence over the all water route to San Francisco. The Sliscovitch mine, and the Hed and Strand property were also worked to a small extent. These properties were in the Nome district and their total production in 1915 was reported to be 132 tons of ore.

American interests and capital have erected a smelter for treating antimony ores in the city of San Luis Potosi in Mexico. They expect to be ready for operation as soon as mining and transportation conditions permit ore to be produced, and the product shipped. It is expected that the plant will employ 150 men, and the capacity is to be 3000 tons per year of Star Antimony. The only antimony smelter heretofore operating in Mexico is located in Wadley, a small station on the National Railway about 100 miles north of San Luis Potosi. The Wadley smelter is not equipped for finishing its products, but has exported the crude antimony to England for further refining. The plant was erected about 14 years ago and has drawn most of its ore from the Catorce district. This district has been by far the best producer for the last 20 years—though antimony has also been found in Durango, Sonora and Oaxaca.

Antimony is ordinarily one of the cheaper metals, selling at from one and one-half to two times the price of zinc; but since the European war it has risen as high as 40 cts. per lb. Some of the higher grades have been practically unobtainable. So long as the war lasts and especially so long as sea traffic is disturbed, the production will be curtailed and prices must remain abnormal, because of the demand for antimony in type metal and especially in bearing metal is fixed and must continue. Other uses, such as its use for coffin trimmings, which consume a surprisingly large quantity of antimony, and from which there is no secondary recovery, might conceivably turn to aluminium or other metals as substitutes.

ANTIMONY STATISTICS OF THE UNITED STATES
(In tons of 2000 lb.)

Year.	Imports, Antimony Content.				Production. (*a*)		
	Metals or Regulus.	In Ore.	Type Metal.	From Domestic Ore.	In Hard Lead. From Domestic Ore.	In Hard Lead. From Imported Ore.	Recovered from Old Alloys, Scrap, Dross, etc.
1904	2,028	1,245	630	486	2,571	.....	.....
1905	2,869	988	1,228	493	2,747	.....	.....
1906	3,950	1,124	1,853	404	1,362	.....	.....
1907	4,331	1,380	1,369	351	1,561	.....	.....
1908	4,057	1,640	422	.....	2,246	.....	.....
1909	4,826	1,693	1,327	.....	1,617	743	1,556
1910	4,950	*Nil.*	1,109	.....	1,598	631	2,779
1911	5,479	*Nil.*	727	.....	1,543	711	2,369
1912	6,969	*Nil.*	52	.....	1,224	725	2,506
1913	7,667	25	50	.....	2,204	304	2,705
1914	6,535	993	94	.....	2,530	175	2,645
1915	8,742	1,682	.....	.....	3,288	.....	.....

(*a*) Figures of U. S. Geological Survey.

For several years the production of antimony in the United States from domestic ores has been confined to that contained in antimonial lead and small quantities recovered in the electrolytic refining of copper and lead. A production of antimony from foreign ores which can only be estimated is also made. The antimonial lead is mostly a by-product and the smelting of the precious metals, and this production can not be largely increased. A quantity saved in electrolytic copper refining can probably be increased—though not enough to make it a serious factor in the market.

Although the production of antimony in antimonial lead is indirect, it is quite as important as a production of an equivalent quantity of segregated antimony, for there is a demand for antimonial lead which would have to be met by alloying the two metals were they not thus produced, and in fact most of the antimony imported both as metal and as ore is thus used.

The values given in the table above for production are arbitrary and must not be taken as exact. Antimonial lead generally contains impurities, such as iron, arsenic and copper, and it is impracticable to obtain pure antimony and pure lead from the alloy at a cost low enough to afford a profit.

MONTHLY AVERAGES FOR COOKSON'S, HALLETT'S, CHINESE AND JAPANESE BRANDS

Month.	Cookson's.	Hallett's.	Chinese & Japanese.
January, 1915	17.56	16.44	15.24
February	20.43	19.25	17.62
March	27.84	24.12	20.93
April	32.07	29.41	23.97
May	No transactions recorded		34.71
June			36.53
July			35.98
August			32.57
September			28.50
October			30.96
November			37.88
December, 1915			39.36
Average			29.52

AVERAGE MONTHLY PRICES OF ANTIMONY IN N. Y. FROM 1910 TO 1914(*a*)
(Cents per pound)

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1910.													
Cookson's	8.500	8.469	8.359	8.438	8.438	8.241	8.175	8.278	8.313	8.263	7.922	7.625	8.252
U. S.	7.988	7.969	7.938	7.938	7.938	7.938	7.938	7.938	7.938	7.900	7.656	7.438	7.876
Others	7.738	7.578	7.313	7.438	7.438	7.438	7.400	7.328	7.313	7.400	7.188	7.063	7.386
1911.													
Cookson's	8.25	8.38	9.56	9.54	9.50	8.75	8.50	8.44	8.31	8.14	7.97	7.78	8.59
U. S.	7.74	8.02	9.13	9.13	8.97			7.94	7.84	7.71	7.61	7.50	8.16
Others	7.5	7.65	9.00	8.52	7.99	7.42	7.35	7.36	7.26	6.96	6.92	6.82	7.54
1912.													
Cookson's	7.53	7.27	7.65	8.05	8.02	8.09	8.42	8.59	9.12	10.30	10.39	10.21	8.90
U. S.	7.47	7.44	7.56	7.75	7.75	7.78	7.96	7.98	8.50	9.62	9.86	9.62	8.26
Ordinaries	6.88	6.83	6.86	6.94	7.10	7.21	7.50	7.70	8.26	9.30	9.30	9.18	7.76
1913.													
Cookson's	9.94	9.47	9.28	9.13	8.88	8.79	8.54	8.38	8.37	7.60	7.62	7.50	8.73
U. S.	9.53	9.09	8.85	8.50	8.37	8.27	8.08	7.91	7.93	7.27	7.30	7.25	8.22
Ordinaries	8.97	8.25	8.18	7.98	7.79	7.64	7.55	7.39	7.37	6.49	6.45	13.9	7.52
1914.													
Cookson's	7.388	7.250	7.315	7.363	7.365	7.250	7.210	17.250	11.830	14.680	17.750	16.130	10.732
U. S.	7.110	7.057	7.073	7.048	7.020	7.000	6.940	15.800	......	......	......	......	......
Ordinaries	6.125	6.100	6.053	6.006	5.845	5.825	5.638	13.800	9.940	12.060	14.450	13.310	8.763

(*a*) From *Eng. Min. Jour.*

Consumption

Roughly the consumption of antimony in the United States is indicated from the antimony produced from the domestic and foreign ore, the secondary or recovered antimony, the antimony and antimonial lead, the import of antimony, the antimony contained in imported type metal and the antimony contained in oxides. In 1910, the antimony consumption amounted to 10,514, short tons; in 1911, 10,502 short tons; in 1912 to 11,476 short tons; in 1913 to 12,755 short tons; and in 1914 to 12,972 short tons.

The following is a detailed report of the domestic consumption of antimony in 1914:

Material and Source.	Tons.	Value.
Antimony contained in antimonial lead from all sources including by-product antimony	2,799	$587,230
Recovered from wastes, scrap, etc. (including some ore), nearly all as alloy	2,645	555,450
Imports:		
Metal	6,555	736,420
Crude antimony and ore (probable antimony content)	1,303	273,630
Total approximate consumption of metallic antimony	13,302	2,152,730

In the United States Tariff schedule antimonial lead is classified as "Type Metal," probably for the reason that it is used so largely for type metal. For years large quantities were "imported" but probably most of this was manufactured in bond in this country from foreign ores. When the foreign demand for the alloy ceases, it will probably again find a market here.

PRODUCTION OF ANTIMONY METAL IN FOREIGN COUNTRIES
(In metric tons)

	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Austria	24	14	36	90	*Nil.*	207	162	*Nil.*	*Nil.*	*Nil.*	13	.....	.....
China(*b*)	.....	.....	.....	3,353	3,829	2,316	9,356	7,937	6,643	6,986	13,531	13,032	19,645
France	1,725	2,748	2,116	2,396	3,433	3,945	3,850	5,444	4,640	4,775	5,406	.....	.....
Hungary(*a*)	683	732	1,007	756	1,322	841	670	695	782	892	859	1,038	.....
Italy	1,574	905	836	327	537	610	345	59	*Nil.*	*Nil.*	*Nil.*	76	138
Japan	528	434	321	190	627	248	198	157	120	97	80	.....	.....

(*a*) Regulus. (*b*) Exports of regulus and refined metal.

Foreign Countries

Bolivia (By Joseph T. Singewald, Jr., and Benjamin LeRoy Miller).—Antimony experienced one of the greatest "booms" known in the history of the metal during 1915, and this stimulated the dormant antimony mining industry of Bolivia to an extent unknown since the Russo-

Japanese war when the price of the metal soared. Whereas in 1914, the Bolivian exports of antimony were 186 metric tons, in 1915 they amounted to 17,923 metric tons. The exported product is hand-sorted stibnite with which is associated a little of the antimony ochre and ranges from 50 to 55 per cent. antimony. The chief producing centers are the Chuquiutu district and vicinity near Uncia; the country around Porco, the ores of which are brought to the railroad at Agua Castilla, a station on the Potosi branch of the Antofagasta and Bolivia Railroad; and the country around and to the south of Atocha, the present terminus of the line being built from Uyuni to the Argentine border to connect with the railroads of that country. During the middle of the year, the first mentioned district was producing at the rate of 15,000 quintals (1 quintal equals about 100 lb.) per month.

The antimony ores are found in the same general region in which the tin ores of Bolivia occur, but not in the same veins. They occur in separate veins, usually having the black Paleozoic shales that make up to such a large extent the eastern range of the Andes as wall rock. While the veins are comparatively narrow in most instances, the filling consists principally of stibnite, with subordinate amounts of quartz as the most abundant gangue mineral. In some cases the value of the ore is greatly depreciated by the presence of galena, in others it is enhanced by the presence of an appreciable gold content.

The mines are chiefly small crudely worked properties in the hands of the Indians who are financed by the purchasers of the ores. During the "boom" of the past year, the Indians searched the mountains for veins of antimony ore and on finding a promising prospect, brought samples to one of the staff of the larger tin mines of the region, a railroad contractor, or other such person. The latter then had the claims denounced and gave the Indian the privilege of working them, paying him so much per quintal for the ore delivered at the railroad. Many antimony mine owners never saw their mines. The price paid the Indians was about one-half the price received for the ore, so that the profits were large and many of the owners were making considerable money in this way simply because they had sufficient capital to wait a few months for the settlements on a shipment, whereas, the Indian lacking capital was forced to realize on his labor at once.

During the latter part of the year the demand for the ore slackened somewhat and the activity was not so great. These events demonstrated however, that Bolivia is capable of furnishing a considerable tonnage of antimony ore when there is an adequate demand.

China.—Between 85 and 90 per cent. of the world's antimony production is mined in four provinces of China: Hunan, Yunan, Kunang-Hsi and Kunang-Tung. Of these, Hunan, has by far the greatest output and that of Kunang-Yung is the smallest. The Wah-Chang Mining Co. control the majority of the antimony mines in China and in the Province of Hunan, they have a complete monopoly. All the products of their mines are sent to Changsha-Hunan, the capital of Hunan Province, to be smelted and refined.

In Hunan, where the Wah-Chang holdings are located, they own mines in the following districts: Yi-Yang, Hsin-Hua, Anhua and Yunlin.

The Yi-Yang mines produce a low grade of ore of approximately from 20 to 25 per cent. antimony, which contain no arsenic. The ores are of the sulphide variety, stibnite, and are smelted by the Herrenschmidt process. This process has been in use by the Wah-Chang Co. since 1911. There are approximately 5000 tons of low-grade ore mined in this district per month, which yield about 1000 tons of crude antimony.

At Hsin-Hua a high-grade ore is mined which runs between 55 and 60 per cent. antimony. In this district there is also found a small quantity of oxide ore. The Yunlin property contains also a very high-grade ore, which carries about 4 or 5 oz. of gold per ton. There is no known method for recovering this gold and accordingly they are storing their ash and slag in order that it might be worked profitably at some future time.

The present output of the Wah-Chang Co. amounts from 800 to 1000 tons of regulus per month. In 1914 they constructed a new plant which was finished and in operation in May, 1915. Japan has come to be an important consuming factor of the metal and doubtless a large percentage of the Chinese production finds its way there.

ARSENIC

By Kenneth H. Read

Nineteen hundred and fifteen, like preceding years has witnessed an increase in the production of white arsenic in the United States. The war, however, had little influence on either the price or the production.

The arsenic resources of the United States are immense, only a few of the many deposits of arsenopyrite (the commonest arsenic mineral) being used. This is due to the fact that such deposits are of but little value unless accompanied by more valuable or precious metals.

Practically all of the arsenic produced in this country is a by-product of the smelting of arsenical lead and copper ores. The arsenic available from this source of supply alone so far exceeds the demand that the present output could be doubled or trebled if the consumption warranted it.

STATISTICS OF WHITE ARSENIC IN THE UNITED STATES

Year.	Production.			Imports.			Total.	
	Pounds.	Value.	Per lb.	Pounds.	Value.	Per lb.	Pounds.	Value.
1900	....	......	.....	5,765,559	265,500	0.04¾	5,765,559	265,500
1901	600,000	$18,000	$0.03	6,989,668	316,525	0.04½	7,589,668	334,525
1902	2,706,000	81,180	0.03	6,110,898	280,055	0.04½	8,816,898	361,235
1903	1,222,000	36,691	0.03	7,146,362	256,097	0.03½	8,368,362	292,788
1904	996,456	29,504	0.03	6,391,566	226,481	0.03½	7,388,022	255,985
1905	1,545,400	50,225	0.03¼	6,444,083	219,198	0.03⅓	7,989,483	269,423
1906	1,663,000	83,150	0.05	7,639,507	336,609	0.04½	9,302,507	419,759
1907	2,020,000	101,000	0.05	9,922,870	553,440	0.05½	11,942,870	654,440
1908	2,603,505	99,193	0.03¾	9,592,881	417,137	0.04⅜	12,196,386	516,330
1909	2,015,880	57,957	0.02⅞	7,183,644	272,493	0.03¾	9,199,524	330,450
1910	2,652,000	66,300	0.02½	8,204,123	250,115	0.03	10,856,123	316,415
1911	6,162,000	123,240	0.02	6,916,069	203,766	0.02⅞	13,078,069	327,006
1912	6,282,000	190,757	0.035	6,205,562	200,616	0.03¼	12,487,562	391,373
1913	4,750,000	142,340	0.03	5,164,768	223,525	0.04⅓	9,914,768	365,865
1914	9,340,000	313,147	0.034	3,188,368	110,121	0.035	12,528,368	361,389

Two or three thousand tons of arsenious oxide (white arsenic) are yearly recovered from flue dust by the American Smelting & Refining Co., the Anaconda Copper Co., and the United States Smelting Co. The prices of arsenic compounds are so low, however, that it is in many cases cheaper to import them from Europe than to pay the higher freight rates across the United States.

Canada, although it has vast deposits of auriferous pyrite in eastern Ontario, Nova Scotia and Cape Breton, not to mention the arsenical silver ores of northern Ontario, produces but little arsenic, while political conditions have prevented the Mexican supply from reaching the United States.

The estimated production of white arsenic in the United States for the year 1915, based on the actual production for the first 10 months was, according to Frank L. Hess of the United States Geological Survey, 5195 short tons, which with a value of 2 cts. per lb. to the smelter represents a total of $207,780.

WORLD'S PRODUCTION OF ARSENIC
(In metric tons)

Year.	Canada. (*a*)	Germany. (*b*)	Italy. (*d*)	Japan. (*a*)	Portugal. (*d*)	Spain. (*b*)	United Kingdom. (*a*)	United States. (*a*)	France. (*d*)
1899........	52	2,423	304	5	1,083	101	3,890	......	2,600
1900........	275	2,414	120	5	1,031	150	4,146	......	4,705
1901........	630	2,549	.....	10	527	120	3,416	272	7,491
1902........	726	2,828	.....	12	736	71	2,165	1,226	5,372
1903	233	2,768	50	6	698	1,088	916	554	6,658
1904........	66	2,829	80	4	1,370	400	992	452	3,117
1905........	*Nil.*	2,535	.....	8	1,562	1,140	1,552	701	3,627
1906........	*Nil.*	3,052	.....	5	1,322	1,114	1,625	754	6,534
1907........	317	2,904	73	7	1,538	2,400	1,523	916	7,900
1908........	649	2,822	451	20	1,655	2,004	2,007	1,301	2,381
1909........	1,020	2,911	*Nil.*	8	1,420	506	2,911	914	2,141
1910........	1,363	3,066	*Nil.*	12	974	444	2,187	1,203	8,045
1911........	1,815	2,981	16	6	887	331	2,178	2,800	19,000
1912	1,858	4,869	*Nil.*	.....	1,006	(*c*)	2,228	2,855	81,880
1913	1,538	....	.....	.....	925	......	1,716	2,158	70,613
1914	1,576	....	.....	.....	....	......	1,722	4,238	......

(*a*) White arsenic. (*b*) Oxide, sulphide, etc. (*c*) Not yet available. (*d*) Ore.

The industrial uses of arsenic are very limited. It is employed in the manufacture of glass, Paris green, London purple and similar insecticides, while a small quantity is used in taxidermy. The minerals realgar and orpiment (disulphide and trisulphide respectively) are used in paint, the former also being used in pyrotechny and in the dyeing of cloth.

ASBESTOS

By Oliver B. Hopkins

The depression in the asbestos industry, which characterized the latter half of 1914, continued for the first part of 1915. During part of that time, especially the winter months, many of the mines of Canada—the chief source of the world's supply of asbestos—had to curtail their operations or to stop work altogether. Early in February the market began to improve and by the middle of the year practically all the mines in Canada had resumed operations. As a whole, the market was more nearly normal in 1915 than in 1914, and although the world production was probably less than during the previous year, there was a pronounced decrease in the stock on hand at its close. At the end of 1915 the market was good, especially for the high-grade material.

The output of asbestos in Canada was only slightly less in 1915 than in 1914, but considerably less than in 1913, the last normal year. The production of asbestos in the United States was greater in 1915 than in the two preceding years and in value the output has been exceeded only by that of three previous years since 1900. As far as statistics are available, the following table shows the world's production of asbestos and indicates the various countries from which it is derived.

WORLD'S PRODUCTION OF ASBESTOS, 1909–1915 (*a*)
(In short tons)

Country.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
United States	3,085	3,693	7,604	4,403	(*k*) 1,100	(*k*) 1,247	(*k*) 1,731
Africa:							
Cape Colony	1,674	1,403	1,253	1,217	(*b*)	(*b*)	(*b*)
Natal	....	3	13	3	(*b*)	(*b*)	(*b*)
Rhodesia	272	332	460	....	325	546	(*j*) 2,216
Transvaal	....	77	....	....	(*b*)	(*b*)	(*b*)
Australia	3	....	....	....	(*b*)	(*b*)	(*b*)
Canada:							
Asbestos	63,349	77,508	101,393	111,561	(*d*) 136,951	(*d*) 96,542	(*h*) 113,115
Asbestic	23,951	24,707	26,021	24,740	(*d*) 24,135	(*d*) 21,031	(*h*) 25,700
Cyprus	172	487	799	860	(*b*)	(*b*)	(*b*)
India	....	3	....	....	(*b*)	(*b*)	(*b*)
Italy	(*e*) 210	(*e*) 193	(*i*) 184	(*i*) 186	(*i*) 169	(*i*) 188	(*b*)
Russia	16,583	13,466	17,124	(*f*) 18,138	(*g*) 18,594	(*b*)	(*b*)

(*a*) Statistics compiled from Mines and Quarries: General Report with Statistics, pt. 4, London, up to 1912.
(*b*) Statistics not available.
(*d*) Report on the mineral production of Canada, calendar year 1913 and 1914, Ottawa.
(*e*) From the *Ministerio delle Finanze*, Rome.
(*f*) *Min. Jour.*, London.
(*g*) *Can. Min. Jour.*, June 1, 1914, p. 370.
(*h*) *Prelim. Rept.*, mineral production of Canada, 1915.
(*i*) *Revista del Servizio Minerario*, Rome.
(*j*) *So. Afr. Min. Jour.*
(*k*) U. S. Geol. Surv., chapter on Asbestos from *Mineral Resources*.

The uses of asbestos in war are suggested by the recent embargo on its shipment from Canada to other than British ports, but which permitted by special licenses granted by the British consul, shipments to France, Russia, Italy, Japan and Portugal. This embargo, had it not been modified, would have caused great hardship to the American manufacturers, who have formerly imported a large percentage of the Canadian production. The embargo was modified so as to permit crude asbestos to enter the United States upon the condition that the manufacturers give a guarantee that none of the crude or manufactured material would be exported from the United States, except as originally designated.

The slackening of the demand for asbestos as a building material, as a heat and electrical insulator and as a fireproof material for industrial uses is offset during the war by its demand for military purposes. It is being used extensively in new naval vessels and as a protection against incendiary bombs.

United States

The embargo on the exportation of asbestos from Canada to this country, which was afterward modified, caused a considerable interest to be taken in the many and widely separated deposits of the United States. Had the embargo been kept in force, it is believed that the deposits of this country could have been developed within a comparatively short time to meet the demand. Asbestos is found in Vermont, Virginia, Georgia, Wyoming, Idaho, Arizona and California. The deposits of Georgia and Idaho are of the amphibole variety and those of the other states are of the serpentine variety, chrysotile.

ASBESTOS STATISTICS OF THE UNITED STATES (a)

Year.	Production.			Imports.		
	Short Tons.	Value.	Value per Ton.	Manufactured.	Unmanufactured.	Total.
1901	747	$13,498	$18.08	$24,741	$667,087	$691,828
1902	1,010	12,400	12.27	33,313	729,421	762,734
1903	887	16,760	18.90	32,058	657,269	689,327
1904	1,480	25,740	17.40	51,290	700,572	751,862
1905	3,100	126,300	40.74	70,117	776,362	846,479
1906	1,695	28,565	16.85	96,162	1,010,453	1,106,615
1907	950	11,700	12.32	200,371	1,104,110	1,304,481
1908	1,350	24,000	17.78	147,548	1,068,342	1,215,890
1909	4,025	87,625	21.77	240,381	993,254	1,233,635
1910	3,630	64,350	18.80	308,078	1,235,170	1,543,248
1911	7,604	119,935	15.77	290,098	1,413,541	1,703,639
1912	4,403	87,959	19.97	363,759	1,456,012	1,819,771
1913	1,100	11,000	10.00	389,664	1,928,705	2,318,369
1914	1,247	16,810	13.48	368,344	1,407,758	1,776,102
1915	1,731	76,952	44.45	137,320	1,981,483	2,118,803

(a) *Min. Resources U. S.*, 1915, U. S. Geol. Survey, chapter on Asbestos.

GENERAL IMPORTS OF ASBESTOS INTO THE UNITED STATES, CALENDAR YEARS 1914 AND 1915 (*a*)

(In short tons)

Country.	1914.			1915.		
	Unmanufactured.		Manufactures of.	Unmanufactured.		Manufactures of.
	Quantity.	Value.	Value.	Quantity.	Value.	Value.
Austria-Hungary	....	....	$47,982	....	....	$10,502
Belgium	....	....	20,267	....	....	....
Canada	71,781	$1,393,732	19,007	93,565	$1,980,749	1,867
Cuba	....	....	....	....	....	538
Denmark	....	....	....	....	....	49
England	....	....	159,098	....	....	106,412
France	....	....	2,863	....	....	139
Germany	11	2,209	104,368	1	734	14,117
Ireland	....	....	236	....	....	....
Italy	2	631	8,020	....	....	2,624
Netherlands	....	....	....	....	....	190
Russia in Europe	72	11,186	....	....	....	....
Scotland	....	....	1,389	....	....	879
Switzerland	....	....	4,984	....	....	....
Mexico	....	....	130	....	....	....
Total	71,866	$1,407,758	$368,344	93,566	$1,981,483	$137,317

(*a*) Statistics of the Department of Commerce.

The value of the manufactured and unmanufactured asbestos imported for consumption into the United States during the calendar years 1909 to 1915 is shown in the following table:

ASBESTOS IMPORTED FOR CONSUMPTION INTO THE UNITED STATES, 1910–1915 (*a*)

Year.	Unmanufactured.	Manufactured.	Total.
1910	$1,235,170	$308,078	$1,543,248
1911	1,413,541	290,098	1,703,639
1912	1,456,012	363,759	1,819,771
1913	1,928,705	378,961	2,307,666
1914	1,407,754	371,469	1,779,223
1915	1,981,484	139,519	2,121,003

(*a*) Statistics of the Department of Commerce.

The marketed production in the United States for 1915 was 1731 short tons valued at $76,952, which represents a gain of 484 tons or 39 per cent. in quantity and $57,987 or 306 per cent. in value.[1]

This pron-grnced increase in the value of the asbestos is due to the yield of highouade fiber from Arizona, which has been considered as good as the best Canadian product.

Arizona.—The first deposits of asbestos in Arizona were found in the Grand Canyon near the town by that name.[2] Similar deposits have been found on Ash Creek 40 miles northeast of Globe where asbestos of a superior grade has been mined since 1914.[3] These deposits have been

[1] Diller, J. S. Preliminary report on the asbestos production for 1915, U. S. Geol. Surv.

[2] For description of this locality, see Diller, J. S., Asbestos: U. S. Geol. Surv., *Mineral Resources* 1913, Pt. 2, pp. 342–347, 1914.

[3] For description see *Idem*, 1914, pp. 96–97, 1915.

exploited by Fisk and Snell and a mill was built on the property in the fall of 1915. During the latter part of that year it was reported that a ton of asbestos per day was being transported on burros to Globe and Rice on the Arizona and Eastern Railroad.

California.—Asbestos is found in a number of counties in California, and for some years past there has been an effort to develop these deposits. During the past year the Trinity Asbestos Mining Co. has been developing their claims which are said to cover 840 acres, and which are located 18 miles northeast of Carville, Trinity County. A road has been built to make the locality accessible and a mill has been built on the property with an estimated capacity of 100 tons of marketable asbestos each working day.

Georgia.—The asbestos deposits of Georgia have been worked for many years and the industry there is older than in any of the other States. The fiber is of a low grade, but is easily and economically mined and suitable for asbestos cement, plaster, asbestos slate and for most of the other uses of low-grade fiber. The Georgia deposits are worked near Gainesville and Hollywood in the northeastern part of the State.

Idaho.—The deposits of asbestos near Kamiah, Idaho, which are similar to those of Georgia, continue to attract attention although as yet they have not been developed.

Vermont.—The southern extension of the Canadian asbestos deposits are found in northern Vermont. A mill was erected and the deposits on Mount Belvedere were worked by the Lowell Lumber and Asbestos Co. for some years, but since 1911 the mines and the mill have remained idle. As described by C. H. Richardson[1] the quantity and quality of the fiber compares favorably with that of the Canadian deposits.

Wyoming.—The deposits of asbestos near Casper, Wyo., have attracted much attention in recent years and some development work has been undertaken but as yet there has been no production. The extent of the asbestos-bearing rock, which consists of serpentine with veins of chrysotile, is known to be great, and although the fiber is not considered of the best grade, the percentage of fiber in the rock is reported to be large.

Foreign Countries

Canada.—The value of the asbestos production of Quebec is equal roughly to 25 per cent. of its total mineral production and the deposits are found in a relatively small area near Thetford and Black Lake. The total output for 1915[2] was 106,558 short tons as compared with 107,668 tons in 1914, a decrease of 1.03 per cent. The sales during 1915 amounted

[1] Report of Vermont State Geologist, 1909–10, pp. 315–330, 1910.
[2] Preliminary report on the mineral production of Canada for 1915, Dept. of Mines, Canada.

to 113,115 tons valued at $3,491,450, an average of $30.87 per ton. As compared with 1914, this shows an increase of 17 per cent. in sales and 20 per cent. in value.

The total quantity of asbestos rock milled during the year is reported as 1,795,472 tons, which with a mill production of 102,571 tons shows an average content of about 5.71 per cent. of asbestos fiber in the rock. The average estimated content of fiber in the rock milled in 1914 was 6.03 per cent.

In the table given below the different grades are based on their valuation: Crude No. 1 comprises material valued at $200 per ton and more; Crude No. 2, that valued at less than $200 per ton; Mill Stock No. 1 includes all mill fiber valued at $30 per ton and more; Mill Stock No. 2, mill fiber valued at $15–$30 per ton; and Mill Stock No. 3, mill fiber valued at less than $15 per ton.

SALES OF ASBESTOS AND ASBESTIC IN CANADA FOR THE CALENDAR YEARS 1896–1915, IN SHORT TONS (a)

Year.	Asbestos.		Asbestic.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1896	10,892	$423,066	1,358	$6,790	12,250	$429,856
1897	13,202	399,528	17,240	45,840	30,442	445,368
1898	16,124	475,131	7,661	16,066	23,785	491,197
1899	17,700	468,635	7,746	17,214	25,446	485,849
1900	21,621	729,886	7,520	18,545	29,141	748,431
1901	32,892	1,248,645	7,325	11,114	40,217	1,259,759
1902	30,219	1,126,688	10,197	21,631	40,416	1,148,819
1903	31,129	915,888	10,548	16,869	41,677	932,757
1904	35,611	1,213,502	12,854	12,850	48,465	1,226,352
1905	50,669	1,486,359	17,594	16,900	68,263	1,503,259
1906	60,761	2,036,428	21,424	23,715	82,185	2,060,143
1907	62,130	2,484,768	28,296	20,275	90,426	2,505,043
1908	66,548	2,555,361	24,225	17,974	90,773	2,573,335
1909	63,349	2,284,587	23,951	17,188	87,300	2,301,775
1910	77,508	2,555,974	24,707	17,629	102,215	2,573,603
1911	101,393	2,922,062	26,021	21,046	127,414	2,943,108
1912	106,520	2,959,677	24,740	19,707	131,260	2,979,384
1913	136,951	3,830,909	24,135	19,016	161,086	3,848,925
1914	96,542	2,892,266	21,031	17,540	117,573	2,909,806
1915	113,115	3,491,450	25,700	21,819	138,815	3,513,269

(a) Obtained from the report of the Director of Mines on the mines and metallurgical industries of Canada for 1907–08, pp. 448, 936. The data for 1909–1915 were obtained from the general summary of the mineral production of Canada.

OUTPUT SALES AND STOCKS IN 1915 IN SHORT TONS (a)

	Output.	Sales.			Stock on Hand, Dec. 31.		
	Tons.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
Crude No. 1	2,305.6	2,735.4	$749,811	$274.11	589.8	$176,533	$299.31
Crude No. 2	1,681.6	2,631.3	322,049	122.39	316.6	43,006	135.84
Mill Stock No. 1.	21,710.0	24,238.0	1,270,074	52.40	2,176.0	91,919	42.24
Mill Stock No. 2.	41,973.0	42,031.0	840,132	19.99	12,837.0	268,197	20.89
Mill Stock No. 3.	38,888.0	41,479.0	309,384	7.46	6,133.0	55,555	9.06
Asbestos	106,558.2	113,114.7	3,491,450	30.87	22,052.4	635,210	28.80
Asbestic	....	25,700.0	21,819	0.85	....	....	....

OUTPUT SALES AND STOCKS IN 1914 IN SHORT TONS (*a*)

	Output.	Sales.			Stock on Hand, Dec. 31.		
	Tons.	Tons.	Value.	Per Ton.	Tons.	Value.	Per Ton.
Crude No. 1	1,450.6	1,335.9	$402,417	$301.23	984.3	$301,237	$306.04
Crude No. 2	2,611.0	2,812.0	370,776	131.87	1,411.0	187,338	132.78
Mill stock No. 1.	16,144.0	19,388.0	932,893	48.12	4,616.0	229,361	49.69
Mill stock No. 2.	58,362.0	47,851.0	963,973	20.15	15,114.0	305,809	20.23
Mill stock No. 3.	29,101.0	25,155.0	222,207	8.83	9,046.0	76,522	8.46
Asbestos	107,668.6	96,541.9	2,892,266	29.96	31,171.3	1,100,267	35.30
Asbestic	....	21,031.0	17,540	0.83	....	....	....

(*a*) Preliminary report on the Mineral Production of Canada for 1915, Dept. of Mines, Canada.

The total sales of crude asbestos during 1915 averaged $199.72 per ton; Crude No. 1 averaged $274.11 and No. 2, $122.39 per ton. The sales of mill stock during the same period averaged $22.46 per ton as compared with $21.64 per ton in 1914. The sales of asbestic increased from 21,031 tons in 1914 to 25,700 tons in 1915 and from an average price of $0.83 to $0.85 per ton.

During 1915 the exports of asbestos amounted to 84,584 tons valued at $2,734,695, an average of $32.45 per ton; and the export of asbestos sand amounting to 25,103 tons valued at $157,410, an average of $6.27 per ton. Imports of manufactures of asbestos for the year amounted to $168,894.

The depression in the asbestos market led to the introduction, in some cases at least, of more modern and economical methods of handling the asbestos rock—to the installation of more powerful units of machinery to reduce the cost of mining and hoisting.

China.—The discovery of asbestos deposits near Pachow in Chungking Province, China, was reported by United States consul E. C. Baker.[1]

The mining expenses and cost of carriage to Chungking amounts to about $0.75 United States currency per 100 lb. The production and exportation of the asbestos is a part of the industrial work for boys carried on by the China Inland Mission of Pachow, Szechwan Province.

Italy.—The asbestos production of Italy in 1914 amounted to 188 short tons valued at $18,383.25, an average price of about $107 per ton. The production in this country never has been great, but is fairly uniform from year to year. The imports into Italy amounted to 2987 short tons in 1914 and the exports for the same year were 560 short tons.

Russia.—The asbestos production of Russia is exceeded only by that of Canada. At the present time no statistics are available for the production of that country since 1913, when it amounted to 18,594 tons.

South Africa.—The production of asbestos in South Africa was

[1] *Min. Jour.*, Sept. 18, 1915, p. 486.

greater in 1915 than in any previous year and the asbestos industry seems well established there. Asbestos was obtained almost entirely from Rhodesia and Cape Colony. There are two types of asbestos produced in South Africa, crocidolite or blue asbestos and chrysotile or serpentine asbestos. Crocidolite is produced in Grigualand West district of Cape Colony. Chrysotile is found in Transvaal and Rhodesia.

The exports of raw asbestos from the Union of South Africa, mainly derived from Kuruman, Hay and Prieska divisions of Cape Colony, for 1913 and 1914 are as follows:[1]

EXPORTS OF RAW ASBESTOS FROM UNION OF SOUTH AFRICA IN 1913 AND 1914

Countries.	1913.		1914.	
	Quantity, Pounds.	Value.	Quantity, Pounds.	Value.
United Kingdom	752,380	$24,445	1,459,757	$57,712
Belgium	....	....	400	15
France	78,288	2,550	89,600	2,920
Germany	594,012	19,111	625,413	18,975
Italy	842,576	27,452	438,718	14,220
United States	4,480	136	....	....

The asbestos mines of the Transvaal were not very active in 1915. The Carolina Asbestos Co., Ltd., which owns some of the important deposits in the Carolina district, reported that no work had been done on their claims during the year. These deposits of chrysotile asbestos are 15 miles east of Carolina on an air line and 22 miles by road. They are found in a mountainous country of the Drakensburg Range. The chrysotile occurs in serpentinized dolomite of the Transvaal System, where it is genetically associated with intrusive sheets of diabase. The chrysotile is found in the dolomite where it is in contact with the intrusive sheet; it is confined to a few feet of serpentinized dolomite which lies upon the diabase and forms thin seams parallel to the bedding planes of the dolomite which dip at low angles.[2]

The asbestos is worked in stopes about 30 in. wide. Veins of asbestos 4 in. wide are occasionally found; the average width is about 0.92 in.

This occurrence of asbestos is very similar to that in Arizona in that it is derived from dolomite through the influence of associated diabase.

The production of asbestos in Rhodesia was the greatest on record. The production for 1915 amounted to 2216 short tons valued at £32,190, or about $72 per ton.[3] The value of the 1914 production amounted to £8612. The total production to the end of 1915 amounted to 5466 short tons.

[1] *Comm. Rep.*, Vice Consul Charles H. Heisler, Cape Town, Feb. 4, 1916.
[2] *So. Afr. Min. Jour.*, Jan. 22, 1916, p. 484.
[3] *So. Afr. Min. Jour.*, Feb. 5, 1916, p. 537.

ASPHALT

By Clifford Richardson

The word "asphalt," a term or name originally limited to the more or less solid forms of native bitumen, is now so loosely used that under this designation the heavier liquid residuals from the so-called asphaltic petroleums are often included.

The standard definition of asphalt as adopted by the American Society for Testing Materials, is as follows:

"Asphalts.—Solid or semi-solid native bitumens, solid or semi-solid bitumens obtained by refining petroleums, or solid or semi-solid bitumens which are combinations of the bitumens mentioned with petroleums or derivatives thereof, which melt upon the application of heat and which consist of a mixture of hydrocarbons and their derivatives of complex structure, largely cyclic and bridge compounds."

The same definition has been proposed by the Committee on Materials for Road Construction of the American Society of Civil Engineers.

If usage is to confirm the application of the term asphalt to other than solid and semi-solid forms of bitumen, new definitions of it will be necessary. In this case the following are suggested:

Crude Asphalt.—Asphalt as found in nature and unchanged by the application of any industrial process.

Liquid Asphalt.—A term loosely used, as asphalt is a solid, to describe a liquid form of bitumen of a highly viscous nature, having a penetration of more than 350 at 77° F. under a weight of 50 gm. for 1 sec.

Semi-solid Asphalt.—A term applied to asphalt to describe a material having a penetration of less than 350 at 77° F. and more than 100 under a weight of 50 gm. for 5 sec.

Solid Asphalt.—A term applied to asphalt to describe a material having a penetration of not more than 100 at 77° F., under a weight of 100 gm. for 5 sec.

Road Asphalt.—An asphalt fluxed to a penetration under standard conditions of 100 to 160.

Strictly speaking asphalt is but one of the forms in which solid native bitumen occurs, being sharply differentiated from gilsonite, grahamite, manjak, ozokerite, which, although solid bitumens, are not true asphalts. For statistical purposes any form of solid native bitumen may be regarded as asphalt, as well as the residuals of petroleums of a certain character recovered by the removal of the more volatile components by distillation. In both cases, they are derivatives of petroleum; in the one produced by natural causes at ordinary temperatures, and in the other at high temperatures, by industrial processes. Unfortunately, as has been said, a sharp line is not always drawn industrially between the residuals so soft as not to be properly regarded as asphalt, and the harder ones having a penetration of less than 100.

As stated in the preceding volume, native asphalt does not originate in nature as such but is the result of slow metamorphosis of certain types of petroleum which takes place usually at or near the surface of the earth by the conversion of effusions of oil into more or less solid bitumen. Asphalt, therefore, originates in petroleums of certain types. However, not all petroleums form asphalt.

In addition to its occurrence in the purer forms, asphalt is also found associated with mineral matter, as in asphaltic limestones and sands, but such occurrences are not regarded to-day as of great commercial importance, although they are exploited for local use. They can not be transported with success to any distance, owing to the freight rates involved in moving the mineral matter with which the bitumen is associated and the competition with the richer forms of material which can be moved more economically.

For the purpose of classification, asphalt may be considered as of two sources of origin, natural and artificial. The first exists in the United States, in industrial quantities, only in the form of gilsonite and grahamite. The main sources of material of this type are the Island of Trinidad, B.W.I., and Venezuela.

The asphalts prepared by industrial processes, which are on the market in the United States, are residuals from the distillation of petroleums, of a more or less asphaltic nature, which are found in California, Texas, Oklahoma and Illinois. They are also prepared from Mexican petroleum.

The statistics in regard to the production of asphalts in the United States are presented by the U. S. Geological Survey in the following form.

The data given are open to criticism from the fact that the three forms which are differentiated by the Survey as follows are not distinguished therein.

"The natural asphalts occur in the United States in three principal forms: (1) As viscous, semi-liquid substances filling interstices and cavities in rock of almost every type, but found mostly in sand, sandstone, and limestone; (2) as viscous and semi-solid tenacious exudations from the earth, either directly from exposed bituminous rocks or from subterranean passages; (3) as solids in the form of veins or irregular bodies, cutting across or lying between layers or masses of rocks."

The tonnage given is made up of material consisting of nearly pure bitumen and includes that of sands which carry but a relatively small proportion, 10 to 15 per cent. When asphalts from all these sources are combined it can be readily seen that the data can be of no great value.

MARKETED PRODUCTION OF NATURAL ASPHALT AND BITUMINOUS ROCK, 1882–1914
(In short tons)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1882	3,000	$10,500	1899	75,085	$533,904
1883	3,000	10,500	1900	54,389	415,958
1884	3,000	10,500	1901	63,134	555,335
1885	3,000	10,500	1902	84,632	461,799
1886	3,500	14,000	1903	55,068	483,282
1887	4,000	16,000	1904	64,167	420,701
1888	50,450	187,500	1905	62,898	305,242
1889	51,735	171,537	1906	73,062	674,934
1890	40,841	190,416	1907	85,913	928,381
1891	45,054	242,264	1908	78,565	517,485
1892	87,680	445,375	1909	99,061	572,846
1893	47,779	372,232	1910	98,893	854,234
1894	60,570	353,400	1911	87,074	817,250
1895	68,163	348,281	1912	95,166	865,225
1896	80,503	577,563	1913	92,604	750,713
1897	75,945	664,632	1914	79,888	642,123
1898	76,337	675,649	1915	75,751	526,490

The data of the Survey in regard to manufactured asphalts are also open to criticism, and even more so than those for natural asphalt, since they include under one classification the solid residuals used in the production of sheet asphalt surfaces, and the heavy liquid residuals used as fluxes and for bituminous road construction, without any differentiation. The impossibility of doing this in a satisfactory way must be recognized, however, under present conditions.

PRODUCTION OF ASPHALT 1913–1915, BY VARIETIES
(In short tons)

Variety.	1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bituminous rock / Maltha	57,549	$173,764	51,071	$162,622	$44,329	$157,083
Wurtzilite (elaterite) / Gilsonite / Grahamite	35,055	576,949				
Wurtzilite (elaterite) / Gilsonite			19,148	405,966	20,559	275,252
Grahamite			9,669	73,535	10,863	94,155
Total	92,604	750,713	79,888	642,123	75,751	526,490
Manufactured or oil asphalt(c)	436,586	4,531,657	360,683	3,016,969	664,503	4,715,583
Total	529,190	5,282,370	438,271	3,647,692	740,254	5,242,073

(c) This item includes material previously referred to as refined bitumen.

State.	1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
California	27,870	$69,825	28,186	$77,810	17,794	$61,485
Kentucky	(b)17,465	(b)60,131	(b)18,935	(b)66,298	(b)19,311	(b)65,352
Oklahoma	16,459	91,416	9,669	73,535	16,907	118,351
Texas	(d)	(d)	(d)	(d)	(d)	(d)
Utah	30,810	529,341	23,098	424,480	(e)21,739	(e)281,302
Total	92,604	750,713	79,888	642,123	75,751	526,490

(a) Included in Oklahoma. (b) Includes Texas. (c) Includes Kentucky. (d) Included in Kentucky.

Imports

The imports of asphalt into the United States of any commercial importance include only those from the natural deposit on the Island of Trinidad, B.W.I., and from Venezuela. During the last 6 years the total imports have reached the amount given in the following table:

ASPHALT IMPORTED FOR CONSUMPTION INTO THE UNITED STATES, 1908–13
(In short tons)

Year.	Crude.		Dried or Advanced.		Bituminous Limestone.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1908	137,808	$532,297	7,642	$67,364	6,224	$20,758	151,674	(a) $624,979
1909	128,109	511,631	10,087	94,146	6,409	18,440	144,605	(a) 633,205
1910	162,435	588,206	20,180	178,704	3,696	9,301	186,311	(a) 785,963
1911	167,681	572,198	20,461	184,954	8,180	23,468	196,322	789,236
1912	193,645	726,345	20,707	177,992	3,976	15,808	218,328	921,145
1913	(b) 207,033	738,452	(c) 14,750	133,336	6,395	38,823	228,178	910,611

(a) Imports for 1908 include $4560 of manufactures, 1909, $8988; 1910, $9752. (b) Includes dried or advanced asphalt for last 3 months of 1913. (c) Last 3 months of 1913 included in crude asphalt.

Some asphalt is also reported as having been imported from Italy, Cuba and several other countries, but the quantity is so small as to be of no great commercial importance.

The following table shows the distribution of the imports:

ASPHALT IMPORTED INTO THE UNITED STATES DURING THE FISCAL YEARS ENDING JUNE 30, 1911 TO 1913, BY COUNTRIES
(Long tons)

Imported from	1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Europe:						
Belgium	89	$538	....	....	....	....
France	....	....	....	....	100	$1,317
Germany	1,898	16,444	1,311	$10,216	913	6,909
Italy	4,619	18,874	50	294	689	4,621
Netherlands	100	598	....	....	....	....
Switzerland	1,235	8,272	785	5,032	640	4,304
United Kindgom	7,721	18,736	5,132	13,128	1,065	12,214
North America:						
Canada	1	28	1	20	32	207
Mexico	64	482	109	1,532	79	1,129
West Indies:						
British	108,216	438,362	97,666	444,413	55,771	327,047
Cuba	9,696	57,804	668	10,866	490	12,189
Danish	....	....	....	....	....	....
South America:						
Columbia	....	....	113	6,894	19	1,057
Venezuela	78,221	390,907	74,849	425,060	23,313	117,760
Asia:						
Turkey	3	639	5	932	12	2,497
Oceania	10	396	....	....	....	....
Total	211,873	952,080	180,689	918,387	83,123	491,251

Exports

The exports of asphalt from the United States consists almost entirely of solid residuals obtained from the distillation of Mexican petroleum. The available data do not furnish a basis for determining accurately the amount thereof.

New Sources of Supply

During the year 1914 no new sources of asphalt, of commercial importance, were developed. Some prominence was given to a discovery in the island of Leite, Philippines, but investigations of this material do not seem to indicate that it can be of any importance.

Unique Character of Trinidad Asphalt

During the last 10 years our comprehension of the relations of surfaces and films and, in connection therewith, of the relation of solids in a colloidal state to any medium or more or less liquid phase in which they are dispersed, has developed to such an extent that it now has extended applications in relation to industrial processes. In 1914 it was first realized that a satisfactory interpretation of the character of Trinidad asphalt and of the principles involved in its use in the construction of satisfactory pavements, must be based on these facts. It has long been recognized that this asphalt possessed certain satisfactory and exceptional qualities which had been demonstrated by service tests extending over a long period of years. It is now appreciated that this is due to the fact that the mineral matter which is associated with the bitumen during the formation of the material consists to a considerable extent of clay which is in a highly dispersed colloidal state, offering a large surface with which the bitumen comes into contact. This involved the development of an enormous amount of surface energy. To this fact the stability of the material is due. Additional surface energy is developed in the combination of this bitumen with mineral matter in a finely divided condition, in the form of fillers and fine sands with which it is combined in the most satisfactory surfaces. A comprehension of the phenomena connected with the relation of surfaces and films has added very largely to the possibilities of the rational interpretation of the lines which must be followed in attaining the best results in the asphalt paving industry, one which has hitherto been founded upon a purely empirical basis.

The surface energy developed by matter in a highly subdivided state, such as that presented when it occurs in a highly dispersed colloid condition, is of enormous importance in connection with structural material involving the bonding of mineral matter with bitumen, since surface energy has been shown to dominate the behavior of such heterogeneous systems.

WORLD'S PRODUCTION OF ASPHALT AND BITUMINOUS ROCK (*a*)
(In metric tons)

Asphalt.

Year.	France.	Germany.	Hungary.	Italy. (*c*)	Spain.	Trinidad. (*b*)	United States. (*e*)	Total.
1905...	20,000	115,267	247	26,838	5,805	116,735	24,737	309,629
1906...	28,231	138,059	4,111	34,386	6,229	132,381	44,430	387,827
1907...	33,000	126,649	3,920	38,568	8,643	147,051	36,656	394,487
1908...	41,000	89,009	4,818	34,761	9,231	136,583	37,389	352,791
1909...	44,800	77,537	5,054	39,165	6,582	146,013	39,640	358,791
1910...	38,500	81,208	4,994	41,705	8,473	161,587	31,159	367,626
1911...	38,000	81,902	3,861	50,179	3,495	163,080	40,307	380,824
1912...	31,535	96,112	4,460	52,707	5,387	176,077	37,570	403,888
1913...	30,892	....	3,024	56,750	5,582	208,164	31,810	....
1914...	....	....	....	38,778	....	....	26,147	....

Bituminous Rock.

Year.	Austria.	France.	Hungary.	Italy.	Spain.	United States.	Total.
1905........	4,363	191,509	19,372	106,586	5,725	32,337	359,892
1906........	2,840	196,375	34,664	130,825	7,794	21,848	394,346
1907........	3,858	177,000	33,096	161,126	8,219	41,301	424,600
1908........	3,695	171,000	72,972	134,163	12,373	33,901	428,104
1909........	2,975	169,000	(*d*)70,000	111,067	5,284	50,243	408,569
1910........	1,066	170,000	(*d*)70,000	162,212	7,795	58,581	469,654
1911......	1,740	169,697	(*d*)60,000	188,133	6,500	38,704	464,774
1912......	4,234	312,000	(*d*)50,000	181,397	....	49,691	....
1913	3,026	324,610	45,860	171,097	....	(*f*)52,220	....
1914	....	....	....	119,853	....	44,257	....

(*a*) Statistics of production in Barbados, Cuba, Mexico, Russia, Switzerland, and Venezuela are not available. (*b*) Exports. (*c*) Including mastic and bitumen. (*d*) Estimated. (*e*) Previously the U. S. statistics included oil asphalt. This is now omitted, leaving only the natural asphalt. (*f*) Includes some maltha.

Trinidad.[1]—As a source of natural asphalt the island of Trinidad has maintained a high rank for many years, owing to the practically unlimited supply of raw material it contains and to the uniform character and high degree of suitability of its product for use in paving. The deposits of commercial importance are situated on La Brea Point, on the western shore of the island, about 30 miles south from Port of Spain, the seat of the local government.

The source of the asphalt exploited in this locality is Pitch Lake, which covers a roughly circular area of about 100 acres, lying at an elevation of 138 ft. above sea level. Borings in the central part and near the sides of the lake show that the bitumen fills a bowl-like depression or crater to a depth of more than 135 ft.

The asphalt of Trinidad is described as occurring in two forms, land pitch and lake pitch, the former occurring in sheets or layers—supposed

[1] *Min. Res. of U. S.*, 1914.

overflows from the lake—and as exudations at the surface of the land from the same source, and the latter, as the name implies, occurring in the lake bed itself. The land pitch seems to have been slightly metamorphosed at the surface by evaporation of the lighter oils and locally hardened by surface fires.

TOTAL EXPORTS OF ASPHALT FROM TRINIDAD, 1910–1914
(In long tons)

Year.(a)	To United States.			To Europe.			To Other Countries.			Grand Total.
	Lake.	Land.	Total.	Lake.	Land.	Total.	Lake.	Land.	Total.	
1910	109,198	9,274	118,472	65,778	150	65,928	......	......	......	184,400
1911	103,590	8,040	111,630	67,105	......	67,105	983	......	983	179,718
1912	95,111	8,600	103,711	85,299	......	85,299	486	......	486	189,496
1913	123,873	1,400	125,273	104,153	......	104,153	605	......	605	230,031
1914	67,357	2,950	70,307	75,297	......	75,297	......	......	......	145,604

(a) Ending Jan. 31 of year succeeding.

Cuba.[1]—According to the official report of the Secretary of Agriculture, Havana, Cuba, the asphalt claims in that country aggregated 7,180 hectares (17,734.6 acres), at the end of June, 1914. The number and distribution of the asphalt workings is given as follows: Pinar del Rio, 34 mines; Havana, 36 mines; Matanzas, 35 mines; Santa Clara, 29 mines; scattered, 11 mines. Total, 145 mines.

Barbados.[1]—Commercial exploitation of the deposits of the hydrocarbon manjak on the island of Barbados continued on a small scale in 1914. The quantity of Barbados manjak invoiced at the Georgetown (Venezuela) consulate for shipment to the United States in 1914 amounted to 59 long tons, having a declared value of $6159, as compared with 112 tons, valued at $9435 in 1913. The quantity imported by the United States is absorbed by the varnish industry.

[1] *Min. Res. of U. S.*, 1914.

BARYTES

The production of crude barytes in the United States in 1915 was 108,547 short tons, valued at $381,032, according to the U. S. Geological Survey. As compared with the production in 1914, which was 52,747 short tons, valued at $155,647, this is a remarkable showing, and reports indicate that the production in 1915 will be continued if not exceeded in 1916.

PRODUCTION OF CRUDE BARYTES IN THE UNITED STATES, 1912–1914, BY STATES, IN SHORT TONS

State.	1913.			1914.			1915.		
	Quantity.	Value.	Average Price per Ton.	Quantity.	Value.	Average Price per Ton.	Quantity.	Value.	Average Price per Ton.
Georgia........	(a)	(a)	(a)	(a)	(a)	(a)	31,027	$102,825	$3.31
Missouri.......	31,131	$117,638	$3.78	33,317	$112,231	$3.37	39,113	158,597	4.05
Tennessee.....}	(b)2,098	3,568	1.70	10,113	16,273	1.61	25,074	71,390	2.85
Kentucky.....}							7,753	28,427	3.67
Other States(c).	12,069	35,069	2.91	9,317	27,143	2.91	5,580	19,793	3.55
Total........	45,298	156,275	3.45	52,747	155,647	2.95	108,547	$381,032	3.51

(a) Included in other states.
(b) Production of Tennessee; no production of barytes reported for Kentucky in 1913.
(c) Includes, 1913: Georgia, North Carolina, South Carolina, and Virginia; 1914: Alabama, California, Georgia, North Carolina, South Carolina, and Virginia; 1915: Alabama, Alaska, California, North Carolina, South Carolina, and Virginia.

Alaska shipped its first barytes in 1915 and it is reported that a grinding mill will be in operation at Sulzer some time in 1916. Deposits have been developed in Colorado but none of the product was marketed in 1915. The Kentucky mines, which have been practically idle for a number of years, made a considerable production in 1915. Georgia and Tennessee mines made remarkable gains in output, through the operations of old producers and newly opened properties. Most of the mines in the Eastern States, even though they marketed no barytes in 1915, report development work and the prospect of large production in 1916. Missouri, which up to the present has always been the largest producer of crude barytes, made an increase in 1915 of over 6000 tons.

The general feeling of the trade is that this boom is not to be short-lived, particularly in view of the large demand for crude barytes by the newly established barium chemical industry.

The following table gives the domestic production of crude barytes in short tons from 1900 to 1915, inclusive:

PRODUCTION OF CRUDE BARYTES, 1900–1915

	Short Tons.		Short Tons.		Short Tons.
1900	67,680	1906	50,231	1912	37,478
1901	49,070	1907	89,621	1913	45,298
1902	61,668	1908	38,527	1914	52,747
1903	50,397	1909	61,945	1915	108,547
1904	65,727	1910	42,975		
1905	48,235	1911	38,445		

IMPORTS OF BARIUM PRODUCTS, 1914–1915
(Fiscal year, ending June 30)

Product.	1914.		1915.	
	Quantity.	Value.	Quantity.	Value.
Baryta, sulphate of, or barytes including baryta earth:				
Unmanufactured tons (2240 lb.)	32,550	$63,260	9,616	$21,087
Manufactured tons (2240 lb.)	5,379	42,625	1,755	14,997
Blanc fixe, or artificial sulphate of barytes, and satin white, or artificial sulphate of lime, pounds	4,752,474	60,641	2,233,369	25,748
Lithopone, pounds	7,245,151	218,133	6,205,245	195,828
Barium carbonate, pounds	4,995,451	46,425	844,588	7,864
Barium binoxide, pounds	6,085,798	330,139	4,084,144	311,262
Barium chloride	6,110,386	67,563	4,686,029	60,532

STATISTICS OF BARYTES IN THE PRINCIPAL COUNTRIES
(Metric tons)

	1911.	1912.	1913.	1914.	1915.
Austria-Hungary (exports)					
Barium chloride	3,741	3,659	4,918		
Barytes	12	2,690	753		
Belgium (production)	25,200	32,400	12,000		
Canada (production)	50	421	582	555	489
France (production)	10,064	13,620	12,236		
Baden (production)	15,014	15,871	16,445		
Bavaria (production)	26,234	27,199	27,199		
Germany (exports)					
Barytes	128,452	142,681	158,065		
Barium white	6,834	8,242	7,647		
Barium chloride	6,180	8,096	5,649		
Barytes (imports)	7,926	18,666	19,466		
Italy (production)					
Barytes, crude	13,620	13,420	12,970	12,970	
Barytes (imports)	2,024	1,986	1,771	1,409	1,319
Barytes (exports)	353	381	234	210	3,288
Spain (production)	635	1,096			
Sweden (imports)	607	644	610		
United Kingdom (production)	43,232	43,453	48,792	46,675	61,713
United States (imports)	21,195	27,093	37,490	26,025	3,460
United States (production)	34,887	34,009	41,105	47,865	98,500

Since the outbreak of the European war the demand for domestic barytes has been greatly increased. As a consequence many abandoned mines and undeveloped deposits have been examined and exploited. A few of these are now being actively operated.[1]

One of the most interesting of these new developments is that of the

[1] J. H. Watkins, *Eng. Min. Jour.*, June 19, 1915.

Cherokee Chemical Co., at Kings Creek, Cherokee County, S. C. A barytes mill was erected at this point several years ago by the Cherokee company and since then small quantities of crude and floated barytes have been produced from time to time. In the past few months, however, a controlling interest in the company has been acquired by outside capital and under the new management better progress is being made. The ore occurs as lenticular veins in quartz-sericite schist. The vein matter is chiefly massive granular barytes, varying in color from pure white to a deep, rose pink. The only impurities which have thus far been observed are occasional veinlets of white quartz, small inclusions of the wall rock, and small amounts of galena, which is mostly segregated along definite lines. The vein matter usually forms a clean, sharp contact with the wall rock, though in places there is a slight gradation into the schist. The veins vary in thickness from a few inches up to 8 ft. or more and conform roughly to the strike and dip of the inclosing schist. Small veinlets forming offshoots from the larger veins are not infrequent, and often cut the structure of the wall rock. In one open-cut three parallel veins, from 1 to 3 ft. in thickness, are being worked. The schists in this area form a series of folds so that the veins show considerable variation in dips. In general the strike is about N. 25° E., and the dip varies from 10° to 45° where exposures were observed.

Nature has played an important part in uncovering the barytes veins in this area, so that a considerable tonnage of ore can be won from open cuts with little stripping. The veins which are exposed for several hundred yards both north and south of the Southern Ry., a short distance east of Kings Creek, dip to the southeast and are roughly parallel to the slope of a hill. Near the base and at the top of the hill they are exposed by erosion, but on the slope the hanging wall, which consists of weathered schist, is from a few inches to 10 ft. in thickness. The ore is at present being mined simply by stripping the veins in open cuts and shooting the massive barytes from the solid.

A plant of considerable size has also been operating at Sweetwater, Tenn., manufacturing barium salts.[1] The source of the raw material is not stated, but it is presumably within a short distance from the plant

[1] M. Toch, *Met. Chem. Eng.*, **14**, 47 (1916).

BISMUTH

Bismuth is one of the metals that command a high price merely because they do not occur in abundance; the price of it is based on the demand and not on the cost of production, which is probably only one-eighth of the selling-price. Not uncommonly bismuth is found as native metal, as in the famous mining district of Schneeberg, in Saxony, and in other places in Bohemia and Saxony. It is also found in Chile, Bolivia, Sweden, Norway, and Australia, usually in association with ores of cobalt, nickel, silver, lead, zinc, and gold. Another important mineral frequently associated with the native metal is bismutite, the hydrous carbonate, and with it is often found bismuthinite, the sulphide. Bismite, the trioxide, is also the source of some bismuth; the three closely similar names being somewhat confusing. Tetradymite, the telluride, which looks like graphite, is also not uncommon.

No bismuth is mined in the United States; the entire domestic production is recovered as a by-product in the electrolytic refining of lead from the anode slime. The plant of the United States Smelting, Refining & Mining Co., at Grasselli, Indiana, and that of the American Smelting & Refining Co., at Omaha, yield 175,000 to 200,000 lb. of the metal yearly. Bismuth also occurs in copper ores, but most of it escapes through the stack in smelting. Blister copper sometimes contains as much as 25 lb. bismuth per ton, but, so far as we know, none is recovered from this source. About an equal amount is imported from Europe, chiefly from Germany, where the European and South American ores are treated, and from England, where ore from South America and Australia is reduced. The ore of the Suan mine, Korea, contains 1.7 lb. bismuth per ton.

No large deposits of bismuth ores have been found in this country, but several small high-grade deposits are known. The Highland Mary mine, at Leadville, has produced 15 per cent. bismuth ore; the Comstock mine, in the La Plata mountains, Colo., has produced ore containing 18 per cent. bismuth; and the Indiana mine, near Ouray, also in Colorado, has produced small lots of ore containing 25 per cent. bismuth. It is interesting to note that to none of these mines was anything paid by the smelters for the bismuth content of the ore, but in fairness it should be added that probably none of the bismuth was recovered in smelting, because the use of electrolytic refining, in which the bismuth is saved, has only recently been adopted by the two plants mentioned. Presumably a fair price would now be paid for the bismuth content of ores, and there seems no reason why the domestic output should not increase sufficiently to take care of domestic consumption at least. It is generally believed in this country that the price of bismuth is strictly controlled by a European syndicate that boycotts any producer found guilty of selling below the established price. If this is the case, it becomes all the more desirable that domestic consumption should be supplied by our own producers.

Bismuth prices seem to be at present a matter of individual bargaining, but are probably \$2.75 to \$3 per lb. in large lots. The only known buyer of bismuth ore in the United States, not a broker, is the American Smelting and Refining Co. There are numerous brokers who handle the ore, among them E. Schaaf-Regelman, 21 State Street, Battery Park Building, New York City, and David Taylor, Boston Building, Salt Lake City, Utah.[1] The London quotation is 10s. per lb.

The following table gives the imports into the United States for the fiscal years since 1905:

Year.	Quantity, Lb.	Value.
1906	243,926	\$378,652
1907	215,647	262,775
1908	225,833	313,919
1909	176,729	274,662
1910	200,221	316,838
1911	178,298	321,360
1912	166,980	305,282
1913	151,030	257,176
1914	133,190	241,448
1915	34,237	72,587

(a) Dept. of Commerce.

PRODUCTION OF BISMUTH MINERALS IN AUSTRALIA
(Tons of 2240 lb.)

Year.	Queensland.	New South Wales.	Tasmania.
	Tons. (a)	Tons.	Tons.
1903	11.0	21.7	....
1904	20.9	40.3	....
1905	15.3	55.8	....
1906	6.5	25.9	....
1907	6.3	16.3	....
1908	22.7	8.7	....
1909	10.3	8.6	....
1910	21.0	6.4	....
1911	9.8	7.9	....
1912	5.0	5.8	....
1913	1.1	9.0	5.0
1914	0.9	....	5.6
1915	2.6	....	5.5

Metallurgy.—In Saxony the ores are first roasted, to free them from sulphur and arsenic, and are then smelted in crucibles with iron and char-

[1] *Min. Cong. Jour.*, Dec., 1915.

coal, the bismuth thus reduced collecting on the bottom of the crucible. The metal may also be recovered in the wet way by treatment with hydrochloric acid, taking the bismuth into solution, from which it can be precipitated by dilution as the oxychloride. This must be redissolved and precipitated several times in order to free it from lead; it is then reduced to the metal by fusion with lime and charcoal. Gold and silver can be separated from the bismuth by the use of zinc, by the process used for de-silverizing lead.

In a recent patent[1] issued to Walter C. Smith, of Chrome, N. J., four processes of refining bismuth by fire methods are given. Preferably these are carried out in the order given here. The molten bismuth is first stirred with sulphur (elemental sulphur, sulphides, or a mixture of sulphates and carbon), and the resulting matte, containing nearly all the copper and the greater part of the contained tellurium, silver, arsenic, antimony, selenium and zinc, some of the tin, and a fair proportion of the lead, is skimmed off. This is most effectively done if the temperature be dropped to 515° to 520° F. after adding the sulphur.

The second process consists in adding caustic soda or other suitable alkali to the molten bismuth. This acts on the arsenic, antimony, selenium, tellurium, sulphur, tin and zinc that may be present, forming a fusible soda slag.

A third treatment consists in stirring in zinc, which affects tellurium, copper, gold, silver, selenium, arsenic, antimony and tin to form an alloy that floats in the bismuth. If, after stirring in the zinc, the temperature be dropped to 550° F., so much of the zinc will be eliminated that if other impurities be not present, the metal may be used for many purposes. If, however, complete removal of the zinc be necessary, this may be accomplished by another sodium-hydrate treatment.

If small quantities of lead, gold and silver still remain after this zincing, then factional crystallization in the manner of the Pattinson process must be used to remove them completely.

Bolivia and Peru.—(By Joseph T. Singewald, Jr., and Benjamin LeRoy Miller.) Bolivia is the principal bismuth-producing country, furnishing more of that metal than all the other countries combined. The production in 1914 was 437 tons of bars and 112 tons of ore estimated to have a total value of $1,200,000. Most of this is shipped to Great Britain, though before the war part went to Germany and Belgium. The *West Coast Leader* of March 2, 1916, gives the exports of bismuth from Bolivia in 1915 at 568 tons, valued at $1,071,125.

The most important producing mines are those of Aramayo Francke & Co. at Tasna, and there is also some bismuth obtained from the mines

[1] U. S. Patent 1166721.

of the same company on Chorolque mountain. The ores are treated at the company's smelter at Quechisla. The Tasna occurrence is the largest known occurrence of bismuth ores and these mines are producing at a rapidly increasing rate. The bismuth ores are associated with the tin and silver ores of that region, and except for small quantities of oxidized material consist for the most part of the sulphide, bismuthinite. Only a small amount of native bismuth is found in these deposits.

Of less importance from a producing standpoint, but of unusual interest on account of the large proportion of native bismuth that they contain, are the ores from Huayni-Potosi to the north of La Paz. As these deposits are so little known compared with the famous Tasna and Chorolque ores, a fuller description of them will be given. Native bismuth and bismuthinite are found in a number of veins in the vicinity, but the most important occurrence is that of the Carmen mine located at an altitude of 16,500 ft., which is being worked by the Huet Brothers. The ores occur in a series of fossiliferous Paleozoic rocks consisting of sandstones and shales, and the ore-body is a zone along the contact of foot-wall quartzite and overlying shale in which the principal minerals are fine-grained cassiterite and pyrite together with chalcopyrite and quartz. Associated with these are sporadic occurrences of bismuthinite and native bismuth. The bismuth minerals occur as small veinlets in the shales and as larger pockets in the other ore minerals which sometimes are of considerable size. One such pocket yielded a mass of native bismuth weighing over 100 lb. which was exhibited at the San Francisco Exhibition. After a preliminary sorting at the mine, the ores are treated at the La Union mill, about 6 km. below the mine and at 600 ft. lower elevation. They are first subjected to hand sorting by Indian women who make a first-class native and a first-class sulphide product, both of which are exported. The remainder is sorted into a second-grade product carrying 5 to 6 per cent. bismuth which is either smelted or exported to Europe for treatment, according to market conditions, and a third-class that averages 2 to 3 per cent. bismuth. The latter is lixiviated and the bismuth recovered as the oxychloride which is smelted to the metallic state for shipment. In 1915, the production was about 6 tons of native bismuth carrying 97 per cent., 120 tons of sulphide ores with 21 per cent. bismuth and 12 tons of oxychloride.

BISMUTH PRODUCTION OF BOLIVIA

Year.	Quantity, Metric Tons.
1912	478
1913	422
1914	460

The bismuth output of Peru comes from the San Gregorio mine which is owned and operated by E. E. Fernandini. It is situated in the department of Junin close to the Cerro de Pasco Railroad, 3 miles south of the Cerro de Pasco smelter and 1 mile southeast of Fernandini's smelter at Hauraucaca. The mine is located near the base of a small knoll that consists of sandstone varying in texture from quartzitic to saccharoidal, and it is in a brecciated mass of this rock that the ore deposit is found. It has been worked in an open cut with a length of 1000 ft. and a width of 80 ft. to a depth of about 20 to 30 ft.

The ore consists entirely of oxidized bismuth compounds and is said to be principally the arsenate. It occurs together with a yellow and brown clay as the matrix of the brecciated sandstone. At a depth of about 30 ft. the bismuth content is said to become very low, but no sulpho-bismuthides or corresponding bismuth minerals have been encountered of which the deposit may represent the gossan.

The average grade of the ore is 2 to 3 per cent. bismuth, and until recently this was subjected to concentration in a wet mill at the Hauraucaca smelter whereby concentrates averaging 18 to 20 per cent. bismuth were obtained and middlings averaging 5 per cent. stored. The mine is affiliated with the bismuth "trust," and its annual output is determined by its allotment and not by its possibilities as a producer. Its allotment during the past few years has been about 25 tons. At the present time mining has been suspended, and the bismuth is being produced by lixiviation of the 10,000-ton pile of middlings that have accumulated during the 10 years that the mine has been in operation. In this treatment, the middlings are roasted and lixiviated with sodium chloride and sulphuric acid. Bismuth sulphide is precipitated from this solution by adding sodium sulphide, and from it native bismuth recovered by smelting. Hence at the present time the native metal is being exported instead of the concentrate. The cost of production is less than one-sixth the average price of bismuth, and the deposit is capable of supplying the entire world's demand for many years.

The output of the mine in tons of metallic bismuth has been:

	Tons.		Tons.
1907	12.8	1912	51.0
1908	8.9	1913	25.3
1909	30.3	1914	25.0
1910	24.1	1915	25.0
1911	24.4		

BORAX

By J. W. Beckman

The production of borax in the United States has remained about normal the past year. Depressed business conditions, it is true, have largely reduced local consumption, but the European war has disturbed production in other countries, and this deficiency has been partly supplied by the California mines, which are the only source in North America. Canada usually imports large quantities from England, but since the declaration of war has drawn upon American refiners for its requirements. The refiners of Austria and Germany have also been badly crippled, and the mines on the Sea of Marmore have been closed by the participation of Turkey in the war.

The world's commerce in borax and boron compounds is largely controlled by Borax Consolidated, an English company with headquarters in London. This company has refineries in England, France, and the United States, and has supplied the German and Austrian refiners with borate ore from its Chilean mines. The Turkish mines are, however, the older producers, and were worked years before the South American deposits were opened. The former have produced about 14,000 tons annually during recent years.

The California mines supply practically all of the borate ores used in this country. Three companies are engaged in this work, the largest of these being Pacific Coast Borax Co. Since the sale of the F. M. Smith interests, this company has been controlled by the Borax Consolidated, with which it had a working arrangement prior to that time. The Pacific Coast company completed much construction work during the past year, including a branch railroad connecting its Biddy McCarthy and Monte Blanco deposits with the Tonopah & Tidewater Railroad at Death Valley Junction, and a calcining plant at the Junction. In this plant the low-grade ore is roasted before shipment. The new railroad opens up some of the richest deposits in the Death Valley region, these being inaccessible heretofore owing to long overland hauls by wagon.

The Sterling Borax Co., with mines situated 6 miles from Lang, in Los Angeles County, is the second largest producer in California. A branch railroad connects these deposits with the Southern Pacific Railroad. During the past year the company is reported to have mined about 15,000 tons of ore. This is divided into two classes: the first grade contains about 31 per cent. anhydrous boric acid, the second about 20 per cent. All of the ore is roasted at the mine before shipment, thereby eliminating the impurities, which consist of clay, pandermite, and water. The colemanite content, upon being roasted is reduced to a fine powder, while the clay and pandermite present retain their original shape. The valuable portion is then readily separated by screening.

After a period of idleness lasting several years, the Russell Borax Mining Co., has again resumed production at its mines in the Ventura district. The control of this company has been acquired by the Stauffer Chemical Co., of San Francisco. During 1914 the period of operation was about 7 months, and 3800 tons was produced. This ore gave an average of between 37 and 38 per cent. A.B.A.

California borate ores supply most of the borax consumed in the United States, as will be seen in the following table of imports:

UNITED STATES IMPORTS OF BORAX, ETC.
(Fiscal years ending June 30)

Year.	Borax.		Borate of Lime, Etc.		Boracic Acid.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1910	9,058	$1,479	19,201	$1,855	416,842	$13,610
1911	7,319	790	13,095	2,277	343,094	12,733
1912	6,409	604	22,784	3,856	276,496	10,540
1913	11,768	882	16,267	2,038	362,400	13,897
1914	466	64	220	29	527,201	22,390
1915	Nil	....	Nil	....	401,684	18,002

The production of borate ores in California is given in the following table:

PRODUCTION OF BORATE ORES IN CALIFORNIA (*a*)
(In tons of 2000 lb.)

Year.	Tons.	Value.	Year.	Tons.	Value.	Year.	Tons.	Value.
1901	7,221	$982,380	1906	58,173	$1,182,410	1911(*d*)	53,330	$1,569,151
1902	(*b*)17,202	2,234,994	1907	53,412	1,200,913	1912(*d*)	42,315	1,127,813
1903	34,430	(*c*)661,400	1908	22,200	1,117,000	1913(*d*)	58,051	1,491,530
1904	45,647	(*c*)698,810	1909	16,628	1,163,960	1914(*d*)	62,400	1,464,400
1905	46,334	1,019,158	1910(*d*)	42,357	1,201,842	1915	67,004	1,663,521

(*a*) Reported by the California State Mining Bureau. (*b*) Mostly refined borax, whence the apparent discrepancy in value. Output of the other years is given as crude material. (*c*) Spot value. (*d*) U. S. Geol. Survey, crude. (*e*) Estimated.

The total production of borate ore in the United States for 1915 was probably about 65,000 tons, although official figures for this period are not yet available.

Refineries are operated in the United States at Bayonne, N. J., Brooklyn, N. Y., New Brighton, Penn., Chicago, Ill., and San Francisco. The San Francisco refineries are operated principally to supply Pacific Coast and Japanese trade.

At a point four miles west of Rich station in the Kramer district, San Bernardino County, colemanite was discovered in 1913 while drilling for water on a ranch. Mineral locations were filed on the land, these being sold to John Ryan, general manager of the Pacific Coast Borax Co. The purchase price was $4000, of which $1000 was paid in cash. The contest between the mineral and agricultural entrants was decided in favor of the former, the evidence showing that the colemanite body was encountered at a depth of 369 ft., below the shale, and continued until a depth of 410 ft., was reached. The testimony brought out the statement from Ryan and his engineers that the deposit was considered sufficiently valuable to justify operation, the ore being exceptionally high grade. Some of this ore gave an analysis of 47.9 per cent. anhydrous boric acid; theoretically, pure colemanite should run 50.9 per cent.

SOME OF THE PRINCIPAL SUPPLIES OF BORAX MATERIALS
(In metric tons)

Year.	Chile. (*a*)	Germany. (*b*)	Italy.			United States. (*c*)	Total. (*d*)
			Borax Refined.	Boric Acid.			
				Crude.	Refined.		
1899	14,951	183	709	2,674	129	18,466	37,112
1900	13,177	232	858	2,491	283	23,437	40,478
1901	11,457	184	544	2,558	347	6,550	21,640
1902	14,327	196	....	2,763	....	15,512	32,798
1903	16,879	159	....	2,583	....	31,232	50,853
1904	16,733	135	569	2,624	314	41,407	61,782
1905	19,612	183	(*e*)1,007	2,700	(*e*)749	42,036	66,287
1906	28,996	161	1,062	2,561	562	52,774	86,116
1907	28,374	114	881	2,305	466	47,945	80,085
1908	35,039	128	(*e*)1,024	2,520	(*e*)429	22,680	61,820
1909	32,218	149	(*e*)1,110	2,431	(*e*)578	37,589	74,075
1910	35,192	167	(*e*) 912	2,502	(*e*)695	38,426	77,894
1911	45,558	160	(*e*) 738	2,648	(*e*)444	48,381	97,929
1912	43,356	224	(*e*) 813	2,309	(*e*)760	38,388	85,850
1913	....	....	(*e*)1,071	2,410	(*e*)743	52,600	....

(*a*) Prior to 1903, figures are for borate of lime exports. (*b*) Boracite. (*c*) Crude borax. (*d*) The total falls short of the world's supply, particularly because it fails to include the important production of Turkey. (*e*) Obtained by treating a part of the crude boric acid reported for the same year.

Chile.—(By Benjamin L. Miller and Joseph T. Singewald, Jr.) Chile continues to hold its place as the foremost foreign producer of borax. In some years the Chilean production has exceeded that of the United States and no doubt for many years to come the two countries will continue to lead the world and will produce approximately equal amounts.

The western range of the Andes of South America, known as the

Cordillera Occidental, extending through Peru, Bolivia, Chile and into Argentine, contains many lofty volcanoes, recently extinct, and from some of which sulphurous gases are still escaping. About the bases of these mountains that rise to altitudes of 15,000 to 19,000 feet are a number of large borax lakes at elevations of 12,000 to 13,000 feet, sufficient to supply the world's demand for borax for several centuries to come. These white encrusted areas extending for miles, as well as the bordering volcanoes that have yielded the borates, are prominent objects of interest to the traveller in the Antofagasta-La Paz Railroad. As yet few of them have been worked. While many of these are owned by the various governments mentioned, or in some cases by individuals, the industry is dominated and controlled by the Borax Consolidated Co., Ltd., owned by English capital. For many years this company has concentrated its efforts at Lake Ascotan, Chile, near the Bolivian border. The Antofagasta-La Paz Railroad skirts the irregular-shaped lake that is about 10 miles in length and approximately 3 miles in width. In certain places there are often pools of water and elsewhere water occurs beneath an encrustation of salts similar to the covering of ice in a pond. In places the deposit consists of practically pure ulexite ($NaCaB_5 \times O_9 - 8H_2O$) in other places mixed with salt and earthy material containing gypsum and glauberite. The purest material is dug, loaded into small cars and hauled to the plant at Cebollar. where it is first sun-dried, later more thoroughly dried by steam heat, and then sacked for shipment. When the treatment plant, which is located on the border of the lake at Cebollar, was erected the difficulty of obtaining fuel caused the company to construct an aerial tram several kilometers in length to a locality where the supply of yareta, a moss-like highly resinous plant growing in rocky slopes, was especially abundant. This was, however, soon exhausted and as the yareta is of such slow growth, new plants have not reached a size sufficient to be collected, and the tram is now idle and fuel must be brought in by the railroad.

Although the borax deposits near Arequipa, likewise controlled by the Borax Consolidated Co., Ltd., are of great promise and Bolivia also possesses a number of borax lakes, it is probable that the demand for South American borax for many years to come will be mainly met by the production from the Ascotan region.

Peru.—It is expected that Peru will shortly become a large producer through an agreement made by Borax Consolidated with the Peruvian government. This arrangement provides that the company shall build furnaces capable of treating at least 40,000 metric tons of borate ore annually, and at its option, the company shall construct either a railway or tram-line connecting the mines near Arequipa with tide-water.

BROMINE AND IODINE

The bromine industry in the United States is carried on principally in Michigan, Ohio and West Virginia. It is difficult to give exact figures of the output since the producers give no information in regard to the industry. The principal producer is the Dow Chemical Co. in Michigan. The bromine wells in and about Pomeroy, Ohio, and Mason City, W. Va., have again been put into active commission, after remaining in a state of idleness for a number of years. The present monthly production will amount to 5 or 6 tons. This amount will contribute notably to lessen the present shortage. It is highly probably that at an early date American manufacturers of bromides will be able to meet the normal demands of domestic consumption.

MARKETED PRODUCTION OF BROMINE IN THE UNITED STATES (*a*)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Pounds.			*Pounds.*	
1900	521,444	$140,790	1908	760,023	$73,783
1901	552,043	154,572	1909	569,725	57,600
1902	513,893	128,472	1910	245,437	31,684
1903	598,500	167,580	1911	651,541	110,902
1904	897,100	269,130	1912	647,200	145,805
1905	1,192,758	178,914	1913	572,400	115,436
1906	1,283,250	165,204	1914	576,991	203,094
1907	1,379,496	195,281	1915	855,857	856,307

(*a*) U. S. Geological Survey.

Iodine

No iodine is produced in the United States, although a possible source exists in the seaweeds along the coast. The seaweeds of California which are treated commercially for potash do not promise a large yield of iodine.

The imports of iodine into the United States are given in the following table:

Year.	Crude and Resublimed.	
	Pounds.	Value.
1910	771,090	$1,051,060
1911	423,408	841,740
1912	379,311	737,109
1913	240,045	525,959
1914	463,333	951,308
1915	612,926	1,332,387

Chile.—(By Joseph T. Singewald, Jr., and Benjamin LeRoy Miller.) Most of the world's output of iodine comes as a by-product of the Chilean nitrate industry. All of the "caliche," as the crude nitrate is called, carries more or less iodine which is present chiefly in the form of sodium iodate. The "caldo," which is the liquor drawn off from the leached "caliche" carries from 1 to 5 gm. of iodine per liter, which remains behind in the "agua vieja" or "mother liquor" after the crystallization of the sodium nitrate. The iodine is recovered from this "agua vieja."

Iodine was first produced in Chile in 1868. The Chilean nitrate industry many years ago developed to the point where it was possible to supply the world's demand for iodine many times over from the iodine content of the "agua vieja," so in 1886 the producers united to form the iodine syndicate which to-day still exercises a rigid control over the iodine market. The purpose of the syndicate is to regulate output and fix prices. Every nitrate "oficina" producing iodine is alloted the portion that it may furnish. This allotment is determined on the basis of the nitrate output of that "oficina" during its first three months' run, and remains the same irrespective of the subsequent nitrate production of that "oficina." Consequently, the "oficina" that expects to furnish iodine prepares for a record run during the first three months in order to get as large an allotment as possible. The iodine need not necessarily be actually produced by the "oficina" to which it is alloted, and as the same company frequently operates a number of plants its entire iodine allotment is usually furnished by only one of these.

The cost of production of the iodine is only from 5 to 7 cts. per oz. and the average price is just about double that figure. Since the iodine production is in the neighborhood of 450 tons, valued at $2,000,000, annually, this makes a nice source of additional profit to the "oficinas" in the combination.

The process used for the extraction of the iodine is essentially the original one, to which very few improvements have been made during the many years it has been in use. Sodium carbonate is prepared by igniting a mixture of sodium nitrate and charcoal. The sodium carbonate is brought into solution in an iron tank above a furnace in which sulphur is burned and the sulphur dioxide allowed to bubble through the carbonate solution, forming an acid solution of sodium bisulphide. The "agua vieja" solution from which the iodine is to be "cut" as the extraction of the iodine is called is run into wooden vats to which enough of the sodium bisulphide solution is added to liberate it. The reaction is allowed to go on for several days in the course of which the iodine settles to the bottom. The tank is emptied by allowing its contents to filter through a bag in which the iodine collects. It is transferred to a press and squeezed to a cake called a "cheese." After a number of "cheeses" have accumulated they are placed in an iron retort and sublimed to yield the refined product. The condenser of the retort consists merely of a series of earthenware pipes about 0.75 m. in diameter, and its length is determined by the amount of material to be sublimed. Most of the iodine collects as a hard cake on the bottom of the condenser, though some hangs from the top in the form of delicate crystals. A typical analysis of the finished product is

	Per Cent.
Iodine	99.50
Non-volatile	0.06
Moisture	0.35

CADMIUM

Cadmium occurs associated with zinc, and is obtained as a by-product in the smelting of zinc ores by means of fractional distillation. The first producer of cadmium in the United States was the Grasselli Chemical Co., which placed its product on the market in 1906. At present there are two producers—the American Smelting and Refining Co. and the Grasselli Chemical Co. During the year 1913 the total production of cadmium was about 26,250 lb. The 1914 production is estimated at 25,000 lb. The Grasselli company obtains its cadmium from the cadmium-bearing blue powder; the American Smelting and Refining Co. gets its cadmium from the bag-house fume.

The imports of cadmium have steadily decreased since 1906 from a value of $10,552. The imports for the fiscal year ending June 30 are shown in the following table:

	Pounds.	Value.
1909	....	$4,643
1910	3,083	1,657
1911	5,956	3,718
1912	6,396	4,603
1913	1,999	1,508
1914	1,543	1,239
1915	264	278

The world's supply of cadmium comes chiefly from Upper Silesia Germany. According to Messrs. Speier, of Breslau, the production for the first quarter of 1913 totaled 9515 kg. During the corresponding period in the year 1914 the production was 8815 kg. The production for 1912 totaled about 29,000 kg. Because of the many small producers the exact production can not be accurately determined.

During 1915 the price ranged from $1.50 to $2 a pound.

Gilbert Rigg has patented a method of removing cadmium from zinc ores by leaching with a sulphuric acid solution containing just enough acid to dissolve the cadmium. When the roasted ore is leached in a hot solution, the cadmium is dissolved in preference to the zinc.[1]

[1] U. S. Patent 1129904. *Eng. Min. Jour.*, Apr. 10, 1915.

CEMENT

By Robert W. Lesley

The year 1915 in the cement industry was in a measure a repetition of the bad year of 1911 which had a serious effect upon the financial fortunes of many of the principal producing plants. While the year 1914 was the first to show a falling-off in production since the establishment of the industry in this country, the year 1915, although showing a slight advance over the previous 12 months, made such a very slight increase—namely, 0.5 per cent.—that it, like its predecessor, might well be classed in the same category.

1915 like 1911, however, was a year of trade wars and bad prices. First and foremost, the closing up of the European sources of capital due to the great war operated to close many South American and other foreign markets to American cement, owing to the slackened demand and the abandonment of many important public works. Further than this, the demand in this country was seriously affected by the conditions of the New York, London and Paris stock markets during the early months of the war which again had the effect of restricting building operations in this country to a marked extent. Naturally, the year opened with a very limited demand and it was not until several months had gone by that building permits began to increase, manufacturers began to extend their plants, railroads began to do additional construction and some increased demand for cement showed itself. But, in the face of this and in the face of reduced production in many of the mills, a trade war arose and produced price-cutting of an abnormal character despite advancing prices for coal and labor at the mills themselves.

The first quarter of the year was a very bad one, both in output and in prices and the second quarter showed little if any improvement in the great producing districts of the Lehigh and New York State. According to the reports of the Geological Survey, the shipments of cement in 1915 were 86,891,681 bbl. against 86,437,956, a gain of 0.5 per cent., and the average factory price per barrel all over the country in 1915 was $0.860 as against $0.927 in 1914, a decrease of nearly 7 cts.

By reference to Table II which is seen below, it will be noted that the great decrease in price was in the Lehigh district of eastern Pennsylvania and western New Jersey and in the New York State district where, although the shipments showed a slight increase, the price fell off from $0.809 per barrel to $0.699 in the first district and from $0.917 per barrel to $0.766 in the second district mentioned. By reference to the same table it will be noted that, with the exception of the territory mentioned considerably over half of the remaining production showed little if any change in price between the years 1914 and 1915, the great decrease being in the districts mentioned. So far as the Lehigh and New York State districts were concerned this falling off in price was doubtless due to decreased demand and excess production and possibly to erroneous business views with regard to proper cost accounting. The results were serious to the whole industry and it was not until toward the end of 1915 that conditions began to stabilize and prices to advance in accordance with the increased demand for cement and in accordance with better business methods embracing systematic and uniform cost accounting and the abolition of many unfair methods of competition.

The result to the cement industry as a whole in 1915 in actual value for cement sold in the face of increased prices for coal and labor is shown in the table below. Taking the total output for the three years 1913, 1914 and 1915 as very near a constant mean of 87,000,000 bbls. of Portland cement, per annum, it will be noted, figuring at the rate of $1.00 per bbl., which was what cement yielded in 1913, that the value to the producers of the cement sold that year would have been for 87,000,000 bbls. about $87,000,000. In 1914 the same 87,000,000 bbls. netted barely $80,000,000. while in 1915 the same 87,000,000 bbls. netted a little short of $75,000,000., thus showing the results of price-cutting in the face of increased costs.

From the report of the Geological Survey, Table I given below shows the cement marketed in the United States in 1913, 1914 and 1915.

TABLE I.—PRODUCTION OF MARKETED CEMENT IN THE U. S. IN 1913–1915, BY CLASSES

Class.	1913.		1914.		1915.	
	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.	Quantity (Barrels).	Value.
Portland	88,689,377	$89,106,975	86,437,956	$80,118,475	86,891,681	$74,726,846
Natural	744,658	345,889	751,285	351,370	750,863	358,627
Puzzolan	107,313	97,663	68,311	63,358	42,678	39,801
Total	89,541,348	$89,550,527	87,257,552	$80,533,203	87,685,222	$75,125,274

Table II shows the distribution of the cement mills into the various recognized districts, the production and shipments in barrels, the active plants and the average factory price per barrel in 1914 and 1915 together with the respective percentages of change.

TABLE II.—PORTLAND CEMENT, 1914–1915

District.	Production and Shipments (Barrels). 1914.	1915.	Percentage of Change.	Average Factory Price per Barrel. 1914.	1915.	Percentage of Change.
Lehigh district (eastern Pennsylvania and western New Jersey):						
Shipments	23,968,554	24,598,950	+ 2.6	$0.809	$0.699	−13.60
Production	24,614,933	24,876,442	+ 1.1			
Stock	3,121,593	3,400,936	+ 8.9			
New York State:						
Shipments	5,474,191	5,275,101	− 3.6	0.917	0.766	−16.46
Production	5,886,124	5,043,889	−14.3			
Stock	954,218	723,019	−24.2			
Ohio and western Pennsylvania:						
Shipments	7,466,887	7,528,383	+ 0.8	0.876	0.855	− 2.40
Production	7,592,065	7,300,498	− 3.8			
Stock	1,100,998	873,112	−20.7			
Michigan and northeastern Indiana:						
Shipments	5,157,613	5,480,428	+ 6.3	0.960	0.944	− 1.67
Production	5,214,557	5,485,951	+ 5.2			
Stock	678,388	682,062	+ 0.5			
Southern Indiana and Kentucky:						
Shipments	2,932,003	2,762,941	− 5.8	0.717	0.703	− 1.95
Production	2,930,735	2,828,561	− 3.5			
Stock	435,742	501,432	+15.1			
Illinois and northwestern Indiana:						
Shipments	11,316,645	10,879,655	− 3.9	0.932	0.907	− 2.68
Production	11,532,605	10,242,869	−11.2			
Stock	2,118,099	1,480,024	−30.1			
Maryland, Virginia, and West Virginia:						
Shipments	2,793,036	3,166,721	+13.4	0.877	0.816	− 6.96
Production	2,784,988	3,193,805	+14.7			
Stock	332,695	359,913	+ 8.2			
Tennessee, Alabama, and Georgia:						
Shipments	2,577,099	3,099,770	+20.3	0.935	0.756	−19.14
Production	2,672,210	3,010,037	+12.6			
Stock	388,839	281,919	−27.5			
Iowa and Missouri:						
Shipments	8,930,465	9,218,820	+ 3.2	0.940	0.882	− 6.1
Production	8,957,613	9,186,401	+ 2.6			
Stock	1,472,723	1,440,304	− 2.2			
Nebraska, Kansas, Oklahoma, and central Texas:						
Shipments	6,016,774	6,517,258	+ 8.3	0.930	0.872	− 6.23
Production	6,253,731	6,274,863	+ 0.3			
Stock	985,611	750,874	−23.8			
Rocky Mountain States (Colorado, Utah, Montana, and western Texas):						
Shipments	2,754,591	2,453,095	−10.9	1.306	1.289	− 1.30
Production	2,698,151	2,472,069	− 8.4			
Stock	210,383	229,324	+ 9.0			
Pacific coast States (California and Washington):						
Shipments	7,050,098	5,910,559	−16.2	1.277	1.375	+ 7.67
Production	7,092,458	5,999,522	−15.4			
Stock	974,174	1,058,247	+ 8.6			
Total:						
Shipments	86,437,956	86,891,681	+ 0.5	0.927	0.860	− 7.23
Production	88,230,170	85,914,907	− 2.6			
Stock	12,773,463	11,781,166	− 7.8			

By Table III the production of Portland cement by States will be seen, together with the number of plants producing and the percentage of change.

TABLE III.—PRODUCTION OF PORTLAND CEMENT BY STATES

State.	1914.		1915.		Percentage of Change, 1915.
	Producing Plants.	Quantity (Barrels).	Producing Plants.	Quantity (Barrels).	
Pennsylvania	20	26,570,151	20	28,648,941	+ 7.8
Indiana	5	9,595,923	5	8,145,401	−15.1
New York	8	5,886,124	7	5,043,889	−14.3
Illinois	5	5,401,605	4	5,156,869	− 4.5
California	7	5,075,114	7	4,503,306	−11.3
Missouri	5	4,723,906	5	4,626,771	− 2.1
Michigan	11	4,285,345	11	4,765,294	+11.2
Iowa	3	4,233,707	3	4,559,630	+ 7.7
New Jersey	3	3,674,800	3	1,579,173	−57.0
Kansas	9	3,431,142	9	3,580,287	+ 4.3
Texas	4	2,100,341	4	1,939,363	− 7.7
Washington	5	2,017,344	5	1,496,216	−25.8
Ohio	5	1,962,047	5	1,948,826	− 0.7
Utah	3	981,100	3	625,577	−36.2
Other States *a*	17	8,291,521	16	9,295,364	+12.1
Total	110	88,230,170	106	85,914,907	−2.6

a Alabama, Arizona, Colorado, Georgia, Kentucky, Maryland, Montana, Nebraska, Oklahoma, Tennessee, Virginia, and West Virginia; Arizona made no output in 1915.

Below in Table IV will be found the shipments of Portland cement by States, together with the average price per barrel sold and the total values.

TABLE IV.—SHIPMENTS OF PORTLAND CEMENT BY STATES

State.	1914.				1915.			
	Shipping Plants.	Quantity (Barrels).	Value.	Average Price per Barrel.	Shipping Plants.	Quantity (Barrels).	Value.	Average Price per Barrel.
Pennsylvania	20	25,985,106	$20,944,787	$0.806	20	28,188,450	$20,252,961	$0.718
Indiana	5	9,540,288	8,342,164	0.874	5	8,577,513	7,336,821	0.855
New York	8	5,474,191	5,020,720	0.917	8	5,275,101	4,039,215	0.766
Illinois	5	5,284,022	4,848,522	0.918	5	5,435,655	4,884,026	0.899
California	7	5,004,633	6,698,905	1.339	7	4,532,452	6,338,918	1.399
Missouri	5	4,706,389	4,485,744	0.953	5	4,628,484	4,007,679	0.866
Iowa	3	4,224,076	4,008,915	0.949	3	4,590,336	4,119,952	0.898
Michigan	11	4,218,429	4,064,781	0.964	11	4,727,768	4,454,608	0.942
New Jersey	3	3,530,476	3,081,205	0.873	3	1,977,474	1,473,499	0.745
Kansas	10	3,237,906	2,643,415	0.816	9	3,780,735	2,826,443	0.748
Texas	4	2,096,140	2,686,653	1.282	4	1,932,828	2,518,233	1.303
Washington	5	2,045,465	2,303,433	1.126	5	1,378,107	1,790,499	1.299
Ohio	5	1,919,859	1,913,797	0.997	5	1,961,409	1,917,920	0.978
Utah	3	974,723	1,317,575	1.352	3	655,116	823,995	1.260
Other States(*a*)	17	8,196,253	7,757,859	0.947	16	9,250,253	7,971,905	0.862
Total	111	86,437,956	$80,118,475	$0.927	109	86,891,681	$74,756,674	$0.860

(*a*) Alabama, Arizona, Colorado, Georgia, Kentucky, Maryland, Montana, Nebraska, Oklahoma, Tennessee, Virginia, and West Virginia; Arizona made no output in 1915.

Referring to the average price per barrel for 1915 as compared with 1914, it will be noted that a complete overturn has occurred in the Lehigh district of eastern Pennsylvania and western New Jersey where in 1914 there was only a moderate decrease of 3.46 per cent. per barrel over the previous year, while in 1915 the percentage of decrease per barrel was 13.60 per cent. The same condition is noted in the New York State district, it having shown only a slight decrease in price in 1914 and showing a falling off in both price and amount of shipments in 1915.

The average price per barrel for the whole country from 1870 to 1915 is shown in Table V below.

TABLE V.—AVERAGE PRICE PER BARREL OF PORTLAND CEMENT, 1870–1914

1870–1880	$3.00	1894	$1.73	1905	$0.94
1881	2.50	1895	1.60	1906	1.13
1882	2.01	1896	1.57	1907	1.11
1883	2.15	1897	1.61	1908	0.85
1884	2.10	1898	1.62	1909	0.813
1885–1888	1.95	1899	1.43	1910	0.891
1889	1.67	1900	1.09	1911	0.844
1890	2.09	1901	0.99	1912	0.813
1891	2.13	1902	1.21	1913	1.005
1892	2.11	1903	1.24	1914	0.927
1893	1.91	1904	0.88	1915	0.860

Table VI shows the fuel used in burning Portland cement and Table VII shows the materials used. The tables follow:

TABLE VI.—STATISTICS SHOWING FUEL USED IN BURNING PORTLAND CEMENT

Fuel.	1914.				1915.			
	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.	Number of Plants.	Number of Kilns.	Barrels.	Percentage of Total.
Coal	88	669	72,471,772	82.1	84	597	70,440,529	82.0
Coal and oil	1	24	4,183,842	4.7	1	24	5,124,074	6.0
Coal, oil, and gas	1	5	712,314	0.8	1	5	729,797	0.8
Coal and gas	2	14	1,564,113	1.8	1	7	830,988	1.0
Oil	14	107	7,698,720	8.7	15	105	7,581,467	8.8
Oil and gas	2	15	1,292,578	1.5	1	5	469,762	0.5
Producer gas	1	1	65,420	0.1	1	1	72,777	0.1
Natural gas	1	4	241,411	0.3	2	10	665,513	0.8
Total	110	839	88,230,170	100.0	106	754	85,914,908	100.0

TABLE VII.—PRODUCTION, IN BARRELS, AND PERCENTAGE OF TOTAL OUTPUT OF PORTLAND CEMENT IN THE U. S. ACCORDING TO TYPE OF MATERIAL USED, 1898–1914

Year.	Type 1. Cement Rock and Pure Limestone.		Type 2. Limestone and Clay or Shale.		Type 3. Marl and Clay.		Type 4. Blast-furnace Slag and Limestone.	
	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.	Quantity.	Percentage.
1899	4,010,132	70.9	546,200	9.7	1,095,934	19.4	....	....
1900	5,960,739	70.3	1,034,041	12.2	1,454,797	17.1	32,443	0.4
1901	8,503,500	66.9	2,042,209	16.1	2,001,200	15.7	164,316	1.3
1902	10,953,178	63.6	3,738,303	21.7	2,220,453	12.9	318,710	1.8
1903	12,493,694	55.9	6,333,403	28.3	3,052,946	13.7	462,930	2.1
1904	15,173,391	57.2	7,526,323	28.4	3,332,873	12.6	473,294	1.8
1905	18,454,902	52.4	11,172,389	31.7	3,884,178	11.0	1,735,343	4.9
1906	23,896,951	51.4	16,532,212	35.6	3,958,201	8.5	2,076,000	4.5
1907	25,859,095	53.0	17,190,697	35.2	3,606,598	7.4	2,129,000	4.4
1908	20,678,693	40.6	23,047,707	45.0	2,811,212	5.5	4,535,300	8.9
1909	24,274,047	37.3	32,219,365	49.6	2,711,219	4.2	5,786,800	8.9
1910	26,520,911	34.6	39,720,320	51.9	3,307,220	4.3	7,001,500	9.2
1911	26,812,129	34.1	40,665,332	51.8	3,314,176	4.2	7,737,000	9.9
1912	24,712,780	30.0	44,607,776	54.1	2,467,368	3.0	10,650,172	12.9
1913	29,333,490	31.8	47,831,863	51.9	3,734,778	4.1	11,197,800	12.2
1914	24,907,047	28.2	50,168,813	56.9	4,038,310	4.6	9,116,000	10.3

Table VIII shows the imports of foreign cement to this country since 1880 and the last figure, that for 1915, indicates that the importation of foreign cement to this country has practically ceased, while Table IX which deals with the exports of cement from 1900 to 1915 throws a light on the increasing market to the south of us—a market which during the last year would have shown much larger figures but for the decreased shipping facilities and the lack of bottoms in which to send the cement to the foreign markets desiring it.

TABLE VIII.—IMPORTS OF FOREIGN CEMENT, 1878–1914, IN BARRELS OF 380 LB.

1880	187,000	1892	2,440,654	1904	968,409
1881	221,000	1893	2,674,149	1905	896,845
1882	370,406	1894	2,638,107	1906	2,273,493
1883	456,418	1895	2,997,395	1907	2,033,438
1884	585,768	1896	2,989,597	1908	842,121
1885	554,396	1897	2,090,924	1909	443,888
1886	915,255	1898	1,152,861	1910	306,863
1887	1,514,095	1899	2,108,388	1911	164,670
1888	1,835,504	1900	2,386,683	1912	68,503
1889	1,740,356	1901	939,330	1913	84,630
1890	1,940,186	1902	1,963,023	1914	120,906
1891	2,988,313	1903	2,251,969	1915	42,208

TABLE IX.—EXPORTS OF CEMENT, 1900–1915, IN BARRELS

Year.	Quantity.	Value.	Percentage of Total.	Year.	Quantity.	Value.	Percentage of Total.
1900	100,400	$225,306	0.6	1908	846,528	$1,249,229	1.6
1901	373,934	679,296	1.9	1909	1,056,922	1,417,534	1.6
1902	340,821	526,471	1.3	1910	2,475,957	3,477,981	3.2
1903	285,463	433,984	0.95	1911	3,135,409	4,632,215	3.9
1904	774,940	1,104,086	2.4	1912	4,215,532	6,160,341	5.1
1905	897,686	1,387,906	2.2	1913	2,964,358	4,270,666	3.2
1906	583,299	944,886	1.1	1914	2,140,197	3,088,809	2.4
1907	900,550	1,450,841	1.7	1915	2,564,713	3,361,451	3.0

In dealing with the condition of the Portland cement industry in the United States, it must not be forgotten that a constant search for new markets is being fostered by the Association of American Portland Cement Manufacturers, one of the great trade associations of the country. The cement road has proven itself a necessity since the advent of the automobile and the statistics of the increasing number of yards laid shows an important new outlet for Portland cement. This, together with the concrete factory which is being to-day so largely constructed for all our new industrial establishments, is likely in 1916 to cause an increase in the consumption of Portland cement and also an appreciable increase in price due to the enlarged demand thus caused.

As a matter of course, the output of natural cement followed that of its more expensive and scientifically made brother, Portland cement, and during 1915 the output was 750,863 bbl. valued at $356,627, a decrease in quantity of 422 bbl. Puzzolan cement, made of slag and hydrated lime mechanically ground together and not chemically combined as in

Portland cement, showed a falling off also, the production for 1915 being 42,678 bbl., a decrease in quantity of 25,633 bbl. compared with 1914.

The standardization of specifications for cement and concrete and reinforced concrete has had much to do with the steady growth in the consumption of Portland cement in this country. Engineering societies represented in various joint committees have worked hard in this field of engineering endeavor and to their coöperation and labors the production of high-grade American Portland cement and the high quality of American concrete construction is largely due and by reason of the standardization of these specifications which relate principally to Portland cement there has been a falling off and practically a restricted growth in the consumption of natural and puzzolan cement, which, though both dealt with in the specifications, are not to-day recognized to the same extent as in former years.

Dealing with trade conditions, Edwin C. Eckel, the well-known geologist and cement expert in his paper read before the Pan-American Scientific Congress held in Washington during December, 1915, referred to the status existing at that time in the industry and said:

"So far our study has brought to light the facts that American cement mills are making a very excellent product, that they are making it very cheaply, and that they are making it in large and increasing annual tonnages. These facts are all very well from the consumer's standpoint; but we can hardly expect the cement manufacturer to be purely and entirely altruistic, so that there remains for discussion the question as to what share in the benefits of the industry may in future be hoped for by the manufacturer."

After speaking of the low prices existing, he stated that "the result of this is that in many cement-producing districts maintenance has been skimped to a dangerous extent, and that all over the United States the average return from the industry has not been sufficient to permit needed and proper development."

He went on to comment upon the economies to be made by consolidation of various mills, the development of by-products, by better management, and economies in freight by distribution from widely scattered plants, and concluded by stating:

"Taking these facts into consideration, we might hopefully forecast a state of affairs in which six or seven large companies will make practically all of the American cement output, each company making up its own large total from the outputs of a number of mills, scattered from coast to coast. Under such conditions it would be practicable to market cement profitably, at reasonable and steady prices, and to develop the export trade as a balance wheel."

The World's Markets

Canada.—The general decrease in production of structural and clay products in 1914 was repeated in 1915, the total quantity of Portland cement, including natural Portland cement, produced in 1915 being 5,153,763 bbl. of 350 lb. each. The imports of cement in 1915 included 1065 bbl. from Great Britain, and 27,125 bbl. from the United States. The figures for Canadian production,[1] sale and consumption follow:

PRODUCTION AND SALES OF PORTLAND CEMENT

	1912.	1913.	1914.	1915.
	Bbl.	Bbl.	Bbl.	Bbl.
Portland cement sold or used	7,132,732	8,658,805	7,172,480	5,681,032
Portland cement manufactured	7,141,404	8,886,333	8,727,269	5,153,763
Stock on hand Jan. 1	894,822	862,067	1,073,328	2,620,022
Stock on hand Dec. 31	903,094	1,089,595	2,628,117	2,062,961
Value of cement sold or used	$9,106,556	$11,019,418	$9,187,924	$6,977,024
Wages paid	$2,623,902	$ 3,466,451	$2,271,006	$1,180,882
Men employed	3,461	4,276	2,977	1,679

CONSUMPTION OF PORTLAND CEMENT

Calendar Year.	Canadian.		Imported.		Total.
	Barrels.	Per Cent.	Barrels.	Per Cent.	Barrels.
1911	5,692,915	90.0	661,916	10.0	6,354,831
1912	7,132,732	83.3	1,434,413	16.7	8,567,145
1913	8,658,805	97.1	254,093	2.9	8,912,988
1914	7,172,480	98.7	98,022	1.3	7,270,502
1915	5,681,032	99.5	28,190	0.5	5,709,222

Belgium.—The Belgian cement industry has been practically destroyed by the war, especially that large part of it manufacturing natural Portland cement in the Charleroi district, much of which territory has been the scene of marching and countermarching by the warring forces. Some of the works have been supplying cement for trench and fortification purposes.

Holland.—Holland, which does not manufacture Portland cement, has been a large importer from Germany, the cement finding its way to that country by water-transportation down the Rhine. Holland has been one of the countries controlled by cartel agreements between it and a large syndicate consisting of German, Belgian, English and Norwegian firms, by which all cement coming into that territory is apportioned and over-importation discouraged. According to consular reports, there is some talk of a Dutch organization to import American Portland cement being formed. Freight rates, however, will likely be destructive of this projected business.

[1] Prelim. Rept., Min. Prod. of Canada, 1915.

Austria-Hungary.—The production of Austria-Hungary has been reduced to one-fifth of that of normal times. Not only has there been limited demand for any building of public works in Austria, but the small export trade has also been lessened so that many of the works are suffering seriously from these conditions. The war has also affected the cement works in Galicia and those in southern Austria.

Germany.—The Association of German Portland Cement Manufacturers has kept up its organization all through the war and held its annual convention which was more sparsely attended than in usual times. Reports in the German paper *Cement,* the organ of the Association, and in *Tonindustrie-Zeitung* show the number of cement manufacturers and their employees who have gone to the war and the large mortality sustained among them. Owing to the present conditions, work on many of the scientific commissions established by the Association has been suspended.

Throughout Germany there has been a large reduction in the output of Portland cement owing to the same conditions that have affected Austria. In certain districts considerable cement has been supplied to the Government for use in trench and fortification work and another interesting development in connection with cement and the war is the fact that great numbers of prisoners, especially Russians, have found employment in the industry during the past year.

The cartel agreements which have governed German Portland cement industry and stabilized production and prevented reckless and destructive competition were favorably commented on by Edward N. Hurley, Vice Chairman, U. S. Trade Commission, in an address before the American Steel and Iron Association.

Russia.—The development of reinforced-concrete construction in Russia has largely increased the demand for cement and in addition to the works in the Volga district and those in south Russia, a new plant has been opened in the Urals producing about 500,000 bbl. a year.

England.—The cement industry has been largely affected by war conditions in England. Primarily, so far as manufacturing is concerned, the increased price of coal due to increased wages and the necessary exportation of English coal to the Allied nations has largely increased the price of cement. While the local demand for the ordinary class of buildings has been much reduced, additions to munition factories and improvements to various plants producing war material have furnished a limited market. The export business has been affected by the diminished buying power of the South American and other foreign lands as well as by the limited supply of shipping room caused by the demand of the war for transportation for soldiers and war materials.

Italy.—In Italy there is an indication that factories producing natural cement both in the northern district as well as near Palermo and in Sicily in the far south are realizing the development of the demand for Portland cement and are beginning to prepare to equip their plants for the production of the latter material.

Turkey.—Two cement works located in the suburbs of Constantinople have a combined yearly output of from 450,000 to 500,000 bbl., all of which for the last year has been taken by the military authorities.

Brazil.—Shipment of American Portland cement in sacks such as are used for the trade here is objected to in Brazil on account of the tropical rains and the general humidity at many consuming points. Notwithstanding this fact, however, American Portland cement is finding a market in Brazil and taking the place of much material that has hitherto come from Germany and England.

A Portland cement works at Sao Paolo was erected many years ago by French capital, but of late years has not been in the market.

Argentine.—As a result of negotiations between the Argentine Department of Public Works and the Department of Commerce in this country, Portland cement passing American standard specifications and so certified has been made acceptable upon public works in the Argentine.

Peru.—A Portland cement company has been recently organized at Lima and is expected to supply a large part of the annual consumption of 100,000 bbl. in that country.

Bolivia.—This country imported in 1915 in the neighborhood of 200,000 bbl. of cement, most of which came from Germany.

Chile.—A set of standards and specifications for the cement and reinforced concrete used in public construction in Chile has been received by the Bureau of Foreign and Domestic Commerce from Commercial Attache V. L. Havens, in Santiago. The standards for cement were compiled by a committee of technical experts and scientific men, who stipulated that the first requisite for the acceptance of any cement by the Government should be a certificate of approval from the testing laboratory of the University of Chile. Besides being subjected to chemical analysis at this laboratory, the cement is tested for weight, fineness, and tensile and compressive qualities. The specifications for concrete construction are based on the standards used in Germany, and represent the application of scientific principles in the determination of dimensions of walls, beams, floors, etc.

The production of cement in Chile has reached an annual output of 120,000 bbl., the two plants at Calera which produce it operating very much upon the same general plan as is adopted in the United States. The coal is slack and comes from the Lota mines in southern Chile.

China.—Owing to the establishment of a Portland cement plant in the Philippines, the shipments from China to these islands have been materially reduced. The effect of the war on Chinese cement industry generally has been very serious and the plants there have greatly suffered by the suspension of railway construction and the stoppage of other sources of demand for the production of the companies.

Japan.—The increase in the shipments of cement from Japan during 1915 amounted to 450,000 casks, valued at $1,046,850, over the preceding 12 months. Since the withdrawal of American shipping from the Pacific, and the increase of Japanese steamship lines in that ocean, the Japanese steamship companies' agencies at Panama and at other Southern American and Central American ports have been very active in seeking markets on the Isthmus and on the west coast of South America for the introduction of Portland cement made by Japanese cement companies. The advantage of heavy freight like Portland cement as ballast in ships carrying the lighter goods of Japan to the various South American markets is expected to be thoroughly availed of by Japanese manufacturers.

South Africa.—In the annual report of the Associated Portland Cement Manufacturers, Limited, of London reference is made to a plant recently established by the corporation in South Africa. This works is said to be meeting a good demand for cement and a doubling-up of machinery is in contemplation.

The Pretoria Portland Cement Co. at its meeting in May, 1915, showed a profit of $300,000 for the preceding year.

Australia.—The failure of Australia's factories to increase their output, the cutting off of shipments from Germany, Austria and Belgium which had furnished nearly 65 per cent. of the total imports, and the difficulty of supplying the demand promptly from other sources caused a scarcity of cement in Australia, and prices rose to a figure not wholly accounted for by the high ocean freights.

India.—In India many enterprises have been affected by the war, but building in which cement is employed is stated to be proceeding in various cities. There is a Portland cement factory of some importance at Madras that manufactures Portland cement according to British standard requirements. It is the only establishment of its kind in southern India.

CHROMIUM

By Samuel H. Dolbear

Macedonian chrome ore has not been available to American consumers for several years because of political turmoil antedating the present European war. During the past year or more, ore from the New Caledonian deposits has been difficult or impossible to secure, and American producers have been obliged to look to California for a supply. Fourteen thousand tons from Canada was shipped in 1915, but this ore was too low-grade to be satisfactory.

All of the larger users of chrome ore have had representation in California, and offers to purchase have resulted in the opening up of many new deposits and the development of some of the old ones.

Prices during 1915 ranged from $11 to $18 per net ton f.o.b. cars at railroad shipping point. The variation in price is due in part to the grade of ore sold, the necessity of the buyer and his ability to secure prices.

The production of chrome in the United States since 1900 is as follows:

Year.	Quantity, (Long Tons).	Value.
1900	140	$1,400
1901	368	5,790
1902	315	4,567
1903	150	2,250
1904	123	1,845
1905	22	375
1906	107	1,800
1907	290	5,640
1908	359	7,230
1909	598	8,300
1910	205	2,729
1911	120	1,629
1912	201	2,753
1913	255	2,854
1914	591	8,715
1915	3,281	36,744

The importations of chrome ore, chromic acid, and chromate of potash are given in the following table:

CHROMATE AND BICHROMATE OF POTASH, CHROMIC ACID, AND CHROME ORE IMPORTED AND ENTERED FOR CONSUMPTION IN THE UNITED STATES, 1909 TO 1915, INCLUSIVE (a)

Year.	Chromate and Bichromate of Potash.		Chromic Acid.		Chrome Ore.		Total Value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		Pounds.		Long Tons.		
1909	537,017	$28,837	7,559	$1,412	39,624	$460,758	$491,007
1910	406,790	19,569	9,850	1,635	38,579	415,768	436,972
1911	22,408	2,159	6,789	1,349	37,540	407,958	411,466
1912	32,913	3,085	8,728	1,376	53,929	499,818	504,279
1913	18,629	1,819	5,562	1,100	65,180	622,821	625,740
1914	31,858	2,375	9,164	1,597	74,686	655,306	659,278
1915	32,942	2,902	3,571	755	76,455	780,061	783,718

(a) Bureau of Foreign and Domestic Commerce.

The quantity and value of imports of chrome yellow or green are given in the following table:

Year.	Quantity, Pounds.	Value.
1909	109,494	$19,492
1910	170,073	23,107
1911	156,586	25,029
1912	156,733	25,516
1913	161,153	24,731
1914	154,933	24,922
1915	49,303	9,492

It will be seen from the above table that the production in California in 1915 was more than sixfold that of any other year shown.

California

Shasta County.—The H. L. Brown mine, which has been for a number of years the principal producing chrome mine in the United States, was sold to the California Chrome Co., consisting of J. B. Huffard, president, Clarence M. Oddie, manager, and others of San Francisco. The property includes four claims, called the Summit, Sunflower, Castle Crag and Blue Jay, located in 1906 and 1908 on Little Castle Creek near Dunsmuir, chiefly in Shasta County but partly in Siskiyou County. Mr. Brown operated the mine to July 23, 1915, when it was taken over by the company. Its production for the year 1915 was much greater than ever before.[1]

During the early part of 1916 the production from this mine is reported to have reached 100 tons per day, later dropping off to about 50 tons.

Alameda County.—Two chrome deposits were developed during 1915 on Cedar Mountain, about 14 miles from Livermore, but no ore was shipped until May, 1916. Both of these deposits have been producers at times, but have been idle for several years.

Amador County.—Messrs. Swanson, Powers & Case are operating a chrome deposit 9 miles from Ione, Amador County, and are making some shipments.

Butte County.—The Zenith Iron Mines Co. produced two carloads of chrome ore in 1915. The mine is situated near Woodleaf in Butte County, and the ore is hauled about 25 miles to Oroville for shipment. The mine was inoperative during the winter months due to bad roads, but commenced shipment again in May, 1916. The owners expect to exhaust the deposit by the production of 1500 to 2000 tons. Three cars were shipped from this same locality by Thorpe and Marchand.

Caleveras County.—The chrome mine at the Ellington Ranch was exhausted with the shipment of about 200 tons in 1915. Other deposits in this locality are not being operated.

[1] *Min. Res. of U. S.*, 1915, U. S. Geol. Surv.

El Dorado County.—The Hill & Hobler mine situated 9 miles from Folsom, was re-opened in May, 1916. Shipments of ore are now being made.

Fresno County.—The deposits of Levensaler Spier Corporation, 10 miles north of Piedra, are the most important yet developed in this County, and there was shipped about 1500 tons during the latter part of 1915 and the early part of 1916. M. L. Curtis & Co. have purchased the Vance deposit about 6 miles from Piedra but production has been limited to a few carloads. W. L. Smith and associates control a number of small deposits in that locality and are producing some ore. The Fyke mine produced several carloads in the first half year of 1916. Other small deposits are being worked in this locality.

Glenn County.—The Black Diamond mine in this County, which formerly produced about 3000 tons, has been sold by W. R. Chesely and associates to the California Chrome Co. This company, of which J. B. Huffard is manager, is believed to be a subsidiary of the Electro-Metallurgical Co. of America. Because of the difficulty of hauling ore over precipitous mountain roads, no production was made in 1915, nor the early part of 1916.

Tehama County.—The Noble Electric Steel Co. controls a relatively large deposit situated about 30 miles from Red Bluff, on Elder Creek. Two or three hundred tons were produced in 1915 but not shipped. The mine has been leased to C. S. Maltby, and preparations are being made to haul ore to Red Bluff for shipment.

San Luis Obispo County.—Messrs. Diblee & Arata, and Loyd Nevell are the principal producers in this County, where many old deposits are being prospected.

Tulare County.—The deposits of D. A. Vaughn, near Porterville were worked in the early part of 1916 by W. D. Corbin and associates. The mine yielded about 1200 tons of ore averaging over 40 per cent. chromic oxide, and were exhausted. The James deposit, also near Porterville, is being operated by R. D. Adams and the ore has been sold to eastern fire-brick manufacturers.

Tuolumne County.—About 200 tons of chrome ore was produced from a deposit near Jamestown during the latter part of 1915. Some ore was also mined at a deposit 30 miles from this town, but it was found impracticable to ship it. Peter Mackey, of Jamestown, has produced small amounts.

Canada

The chrome deposits in the vicinity of Black Lake and Coleraine are credited with an output for 1915 of 14,291 short tons, valued at

$208,718. During the summer months ore averaging less than 30 per cent. chromic oxide found a ready market, but toward the end of the year buyers were insisting on a 35 per cent. ore. By far the greater part of the ore (10,087 long tons) came to the United States at an average price of $11.63 a ton.[1]

Foreign Production

The disturbed condition of Europe, though it stimulated the production of chromic iron ore, greatly interfered with its commercial distribution. Detailed information of foreign production is not available. The principal sources of the ore in recent years have been Rhodesia and New Caledonia.

In Rhodesia, British South Africa, the output for 1915 is reported as 60,581 long tons.

In New Caledonia the output of chromite in 1915 appears to have been about 67,000 tons: that in 1914 was 42,000 tons. There are now blast furnaces at Noumea and Thio, and hydro-electric plants at Tate and Tao.

Russia appears to be the next largest producer. Its output in 1912 was 20,934 tons. Later statistics are not available.

The production of chromic ore in India has increased in late years. In 1914 it was 5888 long tons. Leather tanning with chromium salts is a thriving industry in southern India.[1]

Turkey and Japan produce some chromite, but the annual output of each does not exceed a few thousand tons.

The production in Greece amounted to 6342 metric tons in 1913 and 7059 tons in 1914.

The following table gives the production of various countries since 1905:

THE PRINCIPAL SUPPLIES OF CHROME ORE (*a*)
(In metric tons)

	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Bosnia	186	320	310	500	332	320	250	200	305	533	......
Canada	7,781	7,936	6,528	6,554	2,470	279	143	......	......	123	12,968
Greece	8,900	11,530	11,730	4,350	9,600	9,463	4,615	6,468	6,342	7,059	......
India	2,751	4,445	18,597	4,821	9,398	1,765	3,864	2,936	5,670	5,986	......
Japan	......	......	......	......	......	2,091	1,500	......	......	......	......
New Caledonia (*b*)	51,374	57,367	25,371	46,890	40,000	40,000	82,806	51,516	63,370	......	......
New South Wales	53	15	30	*Nil.*	*Nil.*	*Nil.*	150	23	*Nil.*	......	......
Rhodesia	....	3,308	7,273	12,118	37,024	40,000	47,600	62,850	63,384	49,009	61,590
Russia	27,051	16,969	25,528	10,950	22,213	(*c*)	(*c*)	21,277	......	......	......
Turkey	......	......	21,111	28,394	11,364	......	......	......	......	......	......
United States	22	109	294	364	606	208	122	204	259	601	3,336

(*a*) From the official reports of the respective countries. No complete statistics are available for Turkey or Africa. (*b*) Exports, except 1909 and 1910. (*c*) Statistics not yet available.

[1] *Min. Res. of U. S.*, 1915, U. S. Geol. Surv.

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COAL AND COKE

By A. T. Shurick[1]

In spite of uniform and persistent reports of unparalleled prosperity in all lines, the conservative element in the business world was sufficiently non-committal toward any broad constructive program to apply the brakes more severely than basic conditions seemed to justify when the pace showed indications of becoming too rapid.

One of the most impelling factors was the tremendous expansion in our foreign trade, the close of the year finding the country doing a five billion dollar business, surpassing England in this respect for the first time. Business and trade conditions were uniformly optimistic in every respect. Toward the close of the year it was estimated that the earnings of the Steel Trust alone were on the basis of $250,000,000 annually. The capacity of this tremendous organization was being strained to the breaking point at the year end, production being at the rate of 15,000,000 tons of finished steel per annum, as compared with 9,000,000 tons in 1914 and the record of 12,375,000 tons in 1912. The statements of unfilled tonnage advanced by leaps and bounds, the gross increase for the month of November amounting to over 1,000,000 tons as compared with an increase of 2,250,000 during 9 months in 1909, when negotiations were on an exceedingly active basis.

Other evidences of prosperity piled up with startling rapidity toward the year end. It has been estimated that this country has bought back a billion and a half dollars' worth of railroad securities alone since the great European struggle began. Much of this money has undoubtedly gone toward the purchase of munitions and supplies, it having been conservatively estimated that the cost of the war to the end of the year of 1915 was close to 40 billion dollars, France alone having expenditures at the rate of $420,000,000 dollars a month.

The thoughtful student of the world's affairs stands aghast at the terrible calamity to which Europe is committed, not only from a sense of the keenest sympathy for her peoples, but also because of the sharp disillusionment we have had concerning our own safety. But it is no time for hypocritical protestations concerning the benefits accruing to us. The European demand for commodities of all kinds is insistent and of unprecedented proportions, and we should meet the issue to the best of

[1] Abstracted from *Coal Age*, Jan. 8, 1916, p. 61.

our ability, even as we would expect those same countries to do likewise should we be embroiled in a similar calamity.

As a result of the large contracts taken at the close of 1914 at low prices, the new year opened with the bituminous situation weak, while the industrial outlook was discouraging, and there were large surpluses at all the distributing centers. The base price on the West Virginia grades at Hampton Roads for Boston delivery was $2.85, and some of the large distributors announced an advance on this in February, though it was noted that careful buyers could do somewhat less than the announced circular. Prices gradually went off until in May the best grades were obtainable at $2.50 f.o.b. Norfolk.

Georges Creek grades, shipments on which had fallen behind at the close of 1914, were gradually made up during the opening period of the new year, and when the contract season opened up producers of this coal were very conservative on taking business, it becoming more and more evident that this high-quality fuel will ultimately be diverted to other directions. Determined efforts were made by Pennsylvania operators to invade the New England market at the beginning of the year; a great deal of coal was taken for testing purposes, and some tonnage was covered, though not as large as had been anticipated.

The improvement at interior points, too far removed from seaboard to experience the stimulating effects of the heavy foreign demand, was probably less perceptible. In fact, there was no little disappointment expressed over conditions, though there was undoubtedly a persistent betterment throughout the year, the trouble apparently being that the improvement failed to attain the expected proportions.

As a result of the almost unparalleled publicity given to developments in the export trade, with exaggerated rumors of all kinds following in rapid succession, the final figures when available will prove not only a distinct surprise, but a keen disappointment as well. Conservative estimates based on the best information available at this time show that our exports will be something less than 20,000,000 tons, or a decline of 2,000,000 tons from last year. This is of course due to the severe depression prevailing throughout Canada during most of the year, this market absorbing a large proportion of our exports.

Nevertheless the year has been by far the most important in the history of the American export trade. Excluding the Canadian and other home markets, and turning to what may properly be considered the strictly competitive markets of the world, our coals have made a substantial inroad. The Italian Government has apparently established permanent purchasing arrangements at this end, while test cargoes of American coal have been shipped to many European points and a few contracts for substantial tonnages closed. There has also been a tremendous expansion in our South American trade, the pre-war tonnage of 600,000 per annum having been very nearly trebled in the past year; but in spite of this enormous increase, we are still handling only 15 to 20 per cent. of the business. Great Britain on one side and Australia on the other are aggressively contending for their positions as leaders in each of these respective markets.

The year has witnessed an unusual series of legislative readjustments, particularly as concerns the anthracite industry, though in no case have these been of such a scope that they could be regarded as epoch-making changes in the industry.

The close of 1914 was marked by one of the most drastic decisions affecting the anthracite industry that has been made for some time; that is, the flat reduction of 40 cts. per ton on freights to Philadelphia ordered by the Public Service Commission. This decision was to become effective Jan. 13, but the carriers appealed, putting up a satisfactory bond, guaranteeing refunds in the event of the decision being sustained, so that conditions were nominally unaffected. The matter dragged along throughout the year without any final action, and it was rather lost sight of in subsequent developments.

In October the Interstate Commerce Commission also came forward with a sweeping decision ordering substantial reductions in interstate freights as against the intrastate rates effected by the Public Service Commission to tidewater. This also was appealed, so that both of these rather comprehensive attacks on the anthracite companies, through their carriers, remained in *status quo* at the end of the year.

The closing period of the year was marked by a sharp reaction in the long dullness due to a combination of transportation difficulties, both by rail and water, and to a substantial improvement in industrial conditions creating a broader market and heavier consumption. Car supply in the Pennsylvania district at this time was frequently only 35 to 40 per cent. of requirements.

But in spite of this gratifying spurt, soft spots were still observable at different points. At Down East centers there was unusually aggressive competition for business on the new April contracts. Prices were bid down in a most discouraging manner, and the year end found most of the business in this district closed at figures ranging well under those of even the low period of 1914.

The prompt market, however, was uniformly active and profitable in all directions. Car and labor shortages became more pronounced as the season advanced, this being supplemented by an acute congestion at some of the chief distributing centers. Consumers became apprehensive and prices advanced even faster than had been anticipated, though as a result of the shortage it is highly doubtful if very much business was done at these levels.

Boston, Mass.[1]—The closing months of 1914 gave every indication that 1915 would be another disappointing year, and so it proved for the most part. A moderate demand offshore and a near-panic late in the fall were about all that saved it from a depression similar to that in 1914. The same heedless overproduction in dull times, the same unwholesome scrambling for tonnage far into the future and the same failure of consumers to accumulate fuel were all present in greater or less degree, and taking the coastwise trade by itself, it was not a year of large tonnages. It had most of the features we have come to associate with unsatisfactory seasons.

Shipments of steam coal along the coast were slightly behind 1914, but in view of the 275,000 tons of provincial coal for the New Haven and the Boston & Maine railroads on their last year purchase, the loss was not nearly so great as expected. A deficiency of more than 200,000 tons of anthracite as compared with 1914 can be laid to the mild weather of January and February, together with the slow movement of transportation in the fall. Except for a few conditions that were hopeful, 1915, in the coastwise coal trade, can be regarded first as an indifferent and latterly as an exasperating year.

The year opened with large stocks of bituminous, weak prices, a surplus at every loading port and an industrial situation far from promising, except along special lines. Prices especially were under severe handicap, large contracts having been undertaken late in 1914 at figures so low that buyers were led to expect a soft market. Encouraged also by those shippers who controlled no transportation and were therefore hopeful of low water freights, many of the large consumers were dilatory about entering the market. Until August there were those who bought only their current needs, declining to make season contracts until satisfied the low point of the year had been reached. That condition of itself was hard enough to overcome by midsummer, but there was not even the inducement of firm water freights to relieve the dullness. Every plant having a contract was crowded to accept deliveries, and "market cargoes" multiplied at the distributing points.

It remained for a better business outlook, particularly in textiles, to influence buying. Signs of improvement appeared in June, but not until September did many of the mills resume full time. Through the summer, therefore, the steadying process was very gradual—so gradual it was hardly noticeable. Meanwhile quite a volume of coal had been

[1] G. G. Wolkins, *Coal Age*, Jan. 8, 1916, p. 67.

placed on the same basis as in 1914, and in many instances at 5 cts. to 10 cts. less, regardless of whether Pennsylvania, Maryland or West Virginia coals were purchased. In fact, there was a period of several weeks when purchasing agents were inclined to scoff at any attempt to renew 1914 prices. Even in August a few large buyers still refrained from making contracts.

In September, however, deficiencies of equipment on the coal roads were beginning to be talked of, and when New England railroads actually took on heavy stocks some of the smaller corporations also made the effort to get under cover. Contract demand improved, and late in October there had been enough newspaper comment on slow car movement and the possibility of labor shortage to make New England consumers actively interested. There were many, too, who found business prospects so much better they sought to increase their contracts, and both all-rail and at-tidewater orders accumulated faster than cars or boats. The long-awaited turn came; and December saw not only the makings of the worst railroad congestion yet known, but the highest coastwise freights that have prevailed in a generation.

In September when on-car quotations were at as low a level as at any time during the year there developed a situation which in its bearing on the steam trade in New England was as interesting as it was novel. One of the Boston factors, understood to represent certain New River interests, issued a statement to the trade in which plans were outlined for the use of two steamers, one of 12,600 and the other of 9000 tons, and of a modern re-handling plant on property adjoining Mystic Wharf, both of which would put this firm on a competitive basis with the largest and most aggressive distributors. With this in view the low rate of 75 cts. was named to cover water freight, marine insurance, discharging, weighing and forwarding for delivery inland, Apr. 1, 1916, to Apr. 1, 1917, and naturally this led to marked developments. The offer was closely followed by others from competing distributors. From simply a low re-handling charge that meant $3.60 on cars Boston *if* the Hampton Roads base figure continued at $2.85, quotations slid eventually to $3.30.

This "soft spot" it was expected would be confined strictly to "on cars Boston" and to points where other distributing ports like Portsmouth, Providence, etc., compete with Boston; but early in November the same trend was disclosed alongside wharves of dealers and consumers—first those accessible by lighter from Boston and still later points accessible to steamers and barges. The end of 1915 found practically all the large contract business, outside of railroads, closed for the year ending Apr. 1, 1917, at prices 20 to 40 cts. less than in 1914 or 1915, both admittedly off years, and this in face of as disturbed a season as the trade has experienced since 1902!

Until fall, 1915 could have been emphasized as a notably easy year in which to get anthracite forward at minimum prices. Since late October, however, the pressure has been on the companies to ship and not on the dealers to buy. If only the market could have absorbed a larger output in July and August, there would not have been the shortages along the coast that began to prevail during December. The hard-coal industry is well in hand so far as concerns prices, but there is still an opening for some genius to devise ways of distributing output with less unevenness through the year.

The winter of 1914–15 was very disappointing. Most dealers figured the mild weather made a difference of 10 per cent. in their tonnage for 1915, and undoubtedly it did account for much of the 200,000 tons that Boston was behind Dec. 1, as compared with the year before. There were small spurts in February, but by Mar. 1 dealers were much more concerned about working down stocks for Apr. 1 than about purchases. In fact the spring shipping season was on top of them long before Apr. 1. Several of the companies began loading early in March, withholding invoices until the April reduction was effective. A larger proportion of April coal was received in New England in March than in any previous year. Shipments were very heavy and came forward with such a rush they promised to be all over in a few weeks. But May receipts were larger than in April, and June and July, while light months, proved to be unusually good.

Stocks, therefore, were at their maximum Aug. 1. Buyers had been able to get what sizes they required, there was little restriction even on the proportion of stove and the market settled down for a long period of dullness that was sure to last until coal moved in better volume to the consumer. Mining was curtailed, usually to three days a week; and although there was some complaint, it was realized that the operators were simply narrowing the output to the current needs of the market.

Philadelphia, Penna.[1]—The year 1915 must be recorded in the history of the anthracite trade as one of many unusual developments. Right at the opening of the year came the announcement of the Public Service Commission ordering a reduction of 40 cts. in the freight rates on coal to Philadelphia. This decision was handed down Dec. 12, 1914, to become effective 30 days later, on Jan. 13. In the meantime the railroad companies appealed the decision.

The year, from a weather standpoint, did not begin very auspiciously, as January was an extremely mild month. To add to this the city was in the throes of an industrial depression, so that the retailers were

[1] Abstracted from *Coal Age*, Jan. 8, 1916, p. 79.

generally forced to adopt a strictly cash system, and while they lost many customers, this materially improved their financial position. During the month the mines were operated only about 3 days a week and even so found some difficulty in placing the different sizes. Pea particularly became difficult to move, and stove was also in poor shape, while chestnut was in somewhat better demand.

A continuation of the mild weather through February blasted the hopes of getting a good tonnage for the winter. Coal was offered off circular, and in a number of instances sales were made at the April circular plus the tax. Pea coal became very heavy at this time. Owing to the short working time at the collieries and the consequent curtailment in the production of steam sizes, the market on these grades stiffened.

The legislature was in session at this time, and a bill was introduced with the intention of repealing the anthracite-tax act, but to offset this another act was drawn and passed with the distinct purpose of overcoming any legal objections which had been raised against the 1913 law.

The cool spell that marked the closing days of September extended into October, and the mining companies began to receive orders in good volume. The fact that most dealers urged prompt shipment indicated that the people had but little coal in their cellars. All sizes showed increased strength, and concessions on the circulars were confined to dropping the state tax. Pea moved freely at $2, with persistent rumors that the next month would see a price of $2.25 in effect, although it was known that the large buyers had been protected on the $2 price until Jan. 1. Steam sizes began to move faster as the manufacturing interests realized that a suspension at the mines was more than a possibility. For the first time a car shortage was felt. While it was expected that the month would close with a big tonnage, the final reports showed that the tonnage was somewhat behind the same period of the previous year.

In November the business really began to get into its stride, although a short period of warm weather had a tendency to check the movement to some extent. An interesting feature was the increase in the price of pea coal to $2.25. There was, however, very little coal sold at the new price, as most dealers were protected at the $2 figure until the first of the year. It did nevertheless stimulate buying, as it was rumored that the price would be advanced to $2.50 later on.

As the state tax law of 1913 had just been declared invalid, there was much speculation as to whether the coal companies would refund the amount of the tax. In event of the decision being upheld there seemed to be no way by which the mining companies could be compelled to refund. However, one by one the larger companies issued statements that as soon as all legal obstacles were removed they would turn the money over to their customers. In the meanwhile the state appealed the decision of the court, and the money was again tied up for a more or less indefinite period.

December found the anthracite business moving along steadily, with stove coal in greatest demand. The tendency to maintain wholesale prices grew stronger. Toward the middle of the month pea coal began to sell for \$2.25, and those dealers who were protected on the \$2 price until the first of the year began to call for heavy shipments.

During the month new contract prices were announced, but the companies declined to make contracts for more than the first 3 months of the year. The new prices showed an advance, pea having 5 cts. per ton added, while buckwheat was increased 15 cts. It was also intimated on good authority that on the first of the year a new circular would be issued, increasing the price on all sizes of coal. The reason assigned for the increase was the cost of insuring under the new compensation act that became effective with the first of the year.

Hampton Roads, Va.[1]—The movement of coal from Hampton Roads ports during the year 1915 has broken all previous records.

Of the export coal moving, Italy took the largest amount going to any one country. This movement showed up well all during the spring and summer although it has fallen down somewhat during the latter part of the year. The coal for Italy has been to a large extent contract business and has been for the Italian government for use of both the railways and navy. A considerable amount of this coal has been converted into briquettes. The exportation of coal to Italy would have been considerably heavier but for the scarcity of vessel tonnage and the consequent high freight rate. Freight rates on coal have reached, perhaps, the highest figure ever known and indications are that they will continue high for some time to come.

Export shipments to South American countries have not shown up as well as was anticipated, although they have moved in greater volume than ever before from this port. Brazil has taken the largest portion of the coal moving from Hampton Roads ports with fair quantities to Argentina, Chile and a few scattered cargoes to the various other countries. Freight rates for steam tonnage being high, quite a large fleet of schooners has been employed in this South American business, where, until the present war commenced, practically nothing but steam tonnage was used. Schooner tonnage in addition to taking coal to South America has also been employed in the European trade loading cargoes for Spain, Portugal and even African ports. Freight rates for Spain in

[1] Abstracted from *Coal Age*, Jan. 8, 1916, p. 73.

one instance were as high as $10.50 per ton, this being for a cargo to Barcelona.

Records have been made by the various railroads for fast loading, fast movement from mines and enormous dumpings compared with former years.

Prices on export and coastwise cargoes for standard New River and Pocahontas coals have ranged from $2.65 to $2.90. The prevailing bunker rate, that is contract business, has been $3.30 per ton all year, although this may have been cut in a number of cases on spot business and on American time-chartered boats. The demand for high volatile coals has been somewhat light and in consequence the prices have been rather low, ranging from $2.30 to $2.75, this latter price, however, only being quoted when the demand was heavy in the West.

There was considerable discussion and dissatisfaction on the part of shippers when the railroads here took up the question of changing the present freight rates and also making a change in the charge for docking, undocking and trimming for 1916. After several conferences it was decided that the freight rates remain as they are at present, that is, $1.40 per ton for both cargo and bunker, with a terminal charge of $30 per steamer on bunker vessels. The docking and undocking on bunker vessels, however, has been changed to a new basis of 1ct. per net registered ton. This 1 ct. per ton to cover both docking and undocking will be the 1916 rate.

Pittsburgh, Penna.[1]—The coal industry is one that is traditionally slow in responding to favorable influences, and it is doubtless for this reason that the year 1915 is to be characterized as one of improving prospects rather than of improved conditions actually realized. The Pittsburgh coal district found it a better year than 1914, but the comparison is not particularly favorable, since the latter was exceptionally poor.

A particularly sharp distinction must be made between the Pittsburgh coal districts and the West Virginia and more eastern districts in considering 1915 conditions, for the reason that an influence upon the coal industry in general of the greatest importance was the overseas export demand, and this did not reach the Pittsburgh district to any extent. Indeed, so far as export demand in general was concerned, the Pittsburgh district lost in 1915 even more than in 1914 through there being decreased exports to Canada from the Pittsburgh district and from districts that are competitive in the home market with the Pittsburgh district. Compared with 1913, the last normal year in the export trade, 1915 witnessed a decrease of almost one-half in the exports to Canada, although an increase of one-half in the overseas trade.

[1] B. E. V. Luty, *Coal Age*, Jan. 8, 1916, p. 82.

The year in the Pittsburgh coal trade was really somewhat better than appears from a retrospect of the views entertained from day to day and week to week by members of the trade, for there was continually before the trade prospects of enlarged markets and better prices, although these seemed never to be realized. As a matter of fact, conditions did improve almost continuously through the year, but the realization from month to month fell so far short of the expectations that there was continually a feeling of disappointment, whereas a comparison of conditions at the beginning and at the end of the year shows that there was a very decided improvement. Thus, in the two closing months of 1914 the mines in the district were not operating at more than 40 per cent. of capacity, while in the same period of 1915 they were operating at not far from 75 per cent. of capacity.

As the coal industry is slow to respond to improving conditions, there was little improvement in prices until near the close of the year. At the opening free coal was being sold frequently at $1 per net ton for mine-run, and while higher prices were often realized, there was no time until the opening of Lake navigation that a definitely higher minimum could be quoted. The market responded but little to the millions of tons the Lake trade took from the district, for the movement was quite below expectations.

In the fall the greatly improved industrial conditions, involving a very large increase in the line demand for coal, raised prices out of their rut, and toward the close of the Lake season free coal was quotable at $1.15 for mine-run, while on account of a group of favorable conditions the termination of Lake shipments did not produce a definite weakness in the market, as it usually has done. In the first place the Lake shipments were so light that the loss was unusually small. In the second place there was a further increase in demand from the iron and steel industry and other large consumers, while the railroad consumption increased materially. Thirdly, there was freer stocking of coal by consumers for the winter, as they feared car shortages and had a great deal at stake when they were running their manufacturing establishments at full capacity and at the same time falling behind in filling their orders. Finally, the tone of the market was greatly improved by prospects that there would be heavy stocking against a possible suspension of mining Apr. 1, 1916, a particularly important date, since both the bituminous and anthracite wage scales would expire at that time. The market price of free coal may be said to have advanced 25 cts. during 1915, from $1 to $1.05 up to $1.25 to $1.30 for mine-run.

That the volume of Lake coal demand proved a keen disappointment to Pittsburgh district shippers goes without saying. The tonnage had been particularly poor in 1914, and everyone hoped for a decided reversal in 1915. Stocks at upper Lake ports at the opening of navigation proved unexpectedly large, and hopes that they would be so depleted by the middle of the season as to produce a good ending were not realized.

The light shipments of Lake coal, which is almost wholly ¾ in., had one mitigating circumstance—the market price of slack was well held. A change of fundamental importance is the steady increase in the use slack by line consumers of Pittsburgh coal. For years the iron and steel industry had been installing stokers, not only for steam generation, but for heating and other furnaces employing slack very largely. In the near future the typical consumer will be one who uses slack or crushed coal.

Norfolk & Western Ry.—The following is a statement of the tonnage shipped over this road during the past 4 years:

	1912.	1913.	1914.	1915.
Coal,				
Tidewater, foreign	1,343,311	1,542,950	1,904,306	3,862,538
Tidewater, coastwise	3,583,283	3,805,847	3,763,420	3,188,259
Domestic	17,716,575	18,543,672	19,804,243	22,890,141
Coke,				
Tidewater, foreign	52,762	31,082	1,415	42,311
Domestic	1,416,856	1,499,302	1,017,196	947,985
Total	24,112,787	25,422,853	26,490,580	30,931,234

SHIPMENTS OF ANTHRACITE

	1912.	1913.	1914.	1915.
Reading	12,852,386	12,914,887	11,998,779	11,488,444
Lehigh Valley	11,791,601	13,011,370	13,136,759	12,932,526
N. J. Central	8,342,447	9,002,433	8,024,036	8,017,816
Lackawanna	9,065,622	9,903,541	9,912,578	9,579,053
Del. & Hudson	6,361,238	7,094,258	7,313,541	8,016,988
Pennsylvania	7,435,697	6,351,756	6,434,937	6,124,596
Erie	7,435,697	8,192,352	8,268,585	7,874,062
N. Y. Ont. & West	2,213,382	2,509,031	2,352,486	2,088,577
Total	63,610,587	69,069,628	68,342,601	66,122,062

Chesapeake & Ohio Ry.—The following is a comparative statement of the coal and coke traffic from the New River, Kanawha and Kentucky districts for the 6 months ending Dec. 31, 1913, 1914, and 1915, in short tons:

	1915.	Per Cent.	1914.	Per Cent.	1913.	Per Cent.
Destination:						
Tidewater	2,521,513	20	1,797,457	16	1,614,503	17
East	1,312,001	10	1,280,469	12	1,254,609	14
West	7,936,525	62	7,325,153	67	5,681,077	62
Total	11,770,039	....	10,403,079	....	8,550,189	....
From Connections:						
Bituminous	1,091,351	8	588,433	5	624,276	7
Anthracite	8,274		8,835	....	8,370	....
Total	12,870,815	100	11,000,347	100	9,182,835	100
Coke	193,940	....	90,877	....	180,997	....

Imports and Exports.—The following is a comparative statement of imports and exports of the United States for 1913–14–15, in long tons:

	1913.	1914.	1915.
Imports:			
Anthracite, total	921	19,347	2,998
Bituminous, total	1,413,857[2]	1,375,316	1,521,237
United Kingdom	6,141	27,421	18,361
Canada	1,096,924	1,050,592	1,253,829
Japan	117,483	75,109	86,919
Australia	188,613	219,941	159,241
Other countries	4,696	2,253	2,887
Coke	93,507[2]	120,777	47,520
Exports			
Anthracite, total	4,154,386	3,830,244	3,542,971
Canada	4,083,333	3,767,774	3,440,009
Argentina	....	....	2,526
Brazil	....	6	2,415
Uruguay	84	....	605
Other countries	70,969	62,464	97,416
Bituminous, total[1]	17,986,757	13,801,850	16,762,283
Italy	....	....	2,931,581
Canada	13,496,190	9,170,901	8,354,375
Panama	489,761	267,598	515,341
Mexico	477,046	359,802	276,433
Cuba	1,275,538	1,074,825	1,165,871
West Indies	608,762	552,600	529,423
Argentina	70,048	241,248	786,967
Brazil	279,933	278,026	617,304
Uruguay	16,858	76,088	158,201
Other countries	1,272,621	1,780,762	1,426,787
Total coal	22,141,143	17,632,094	20,305,254
Coke	881,603	592,487	799,444
Bunker coal	7,700,520	7,266,002	7,464,630

[1] Beginning Oct. 4, 1913. [2] For part year only.

Coal in the United States

PRODUCTION OF COAL IN THE UNITED STATES.

State.	1914.		1915.	
	Quantity.	Total value.	Quantity.	Total value.
Alabama	15,593,422	$20,849,919	14,927,937	$19,066,043
Arkansas	1,836,540	3,158,168	1,652,106	2,950,456
California, Idaho, and Nevada	13,974	39,821	12,503	32,054
Colorado	8,170,559	13,601,718	8,624,980	13,599,264
Georgia	166,498	239,462	134,496	231,861
Illinois	57,589,197	64,693,529	58,829,576	64,622,471
Indiana	16,641,132	18,290,928	17,006,152	18,637,476
Iowa	7,451,022	13,364,070	7,614,143	13,577,608
Kansas	6,860,988	11,238,253	6,824,474	11,360,630
Kentucky	20,382,763	20,852,463	21,361,674	21,494,008
Maryland	4,133,547	5,234,796	4,180,477	5,330,845
Michigan	1,283,030	2,559,786	1,156,138	2,372,797
Missouri	3,935,980	6,802,325	3,811,593	6,595,918
Montana	2,805,173	4,913,191	2,789,755	4,526,509
New Mexico	3,877,689	6,230,871	3,817,940	5,481,361
North Dakota	506,685	771,379	528,078	766,072
Ohio	18,843,115	21,250,642	22,434,691	24,207,075
Oklahoma	3,988,613	8,204,015	3,693,580	7,435,906
Oregon	51,558	143,556	39,231	111,240
Pennsylvania, bituminous	147,983,294	159,006,296	157,955,137	167,419,705
South Dakota	11,850	20,456	10,593	16,384
Tennessee	5,943,258	6,776,573	5,730,361	6,479,916
Texas	2,323,773	3,922,459	2,088,908	3,445,487
Utah	3,103,036	4,935,454	3,108,715	4,916,916
Virginia	7,959,535	8,032,448	8,122,596	7,962,934
Washington	3,064,820	6,751,511	2,429,095	5,276,299
West Virginia	71,707,626	71,391,408	77,184,069	74,561,349
Wyoming	6,475,293	10,033,747	6,554,028	9,555,804
Total bituminous	422,703,970	493,309,244	442,624,426	502,037,688
Pennsylvania, anthracite	90,821,507	188,181,399	88,995,061	184,653,498
Grand total	513,525,477	681,490,643	531,619,487	686,691,186

MANUFACTURE OF COKE IN THE UNITED STATES.

(In short tons).

State.	1913.		1914.		1915.
	Coal used.	Coke produced.	Coal used.	Coke produced.	Coke produced.
Alabama	5,218,323	3,323,664	4,678,196	3,084,149	3,071,811
Colorado	1,349,743	879,461	1,048,251	666,083	670,938
Georgia	82,871	42,747	45,298	24,517	20,039
Illinois	2,481,198	1,859,553	1,932,132	1,425,168	1,686,998
Indiana	3,535,136	2,727,025	3,125,207	2,276,652	2,768,099
Kentucky	512,245	317,084	672,624	443,959	526,097
New Mexico	788,172	467,945	660,501	362,572	389,411
New York	1,067,207	758,486	659,418	457,370	684,461
Ohio	507,417	351,846	745,097	521,638	684,658
Pennsylvania	43,195,801	28,753,444	30,286,961	20,258,393	25,622,862
Tennessee	694,085	364,578	487,446	264,127	256,973
Virginia	2,015,259	1,303,603	1,319,901	780,984	629,807
West Virginia	4,034,251	2,472,752	2,316,309	1,427,962	1,391,446
Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Jersey, Utah, Washington, Wisconsin	3,299,345	2,345,329	3,184,139	2,222,134	3,177,550
Total	69,239,190	46,299,530	51,623,750	34,555,914	41,581,150

Alabama.[1]—Until Oct. 1, 1915, it appeared that the coal and coke tonnage of Alabama for the year 1915 would fall below the figures for all the years subsequent to 1909, but the sudden revival of the furnace demand during the last 3 months of the year brought the total coal production to the 15,000,000-ton mark. The coke output will be approximately 3,000,000 tons, as compared with 3,084,149 tons in 1914.

The number of lives lost on account of accidents was only 63, which is the lowest number since 1902, and on the basis of tons mined per life lost is the best record made in the State. There have been no labor disturbances of any kind during the year nor shortage of railroad cars though during the last 2 weeks of the year, while the railroads were stocking coal to carry them through the holidays, some miners were not able to get all the cars that they could have loaded.

Few of the mines of the state averaged better than half time from January till October, but during the last 3 months of the year the mines operated by the companies owning blast furnaces ran full time and the others worked about 5 days per week. The unseasonable weather held down the price of domestic coal, and the railroads did not take over 50 per cent. of the minimum tonnage called for by their contracts until late in November. Railroads whose contracts expired July 1 renewed them at a lower price per ton than has been accepted for years.

The coke industry was the first to feel the revival of business due to the war. Because of the high prices offered for by-products, the coke itself became almost the by-product, and the by-product plant owners ran their ovens to capacity and stocked all of the coke that they could not dispose of. Two companies—the Woodward Iron Co. and the Tennessee Coal, Iron and Railroad Co.—built benzol plants at their by-product ovens. The Tennessee plant is one of the largest in the world and is of the still type. The demand for foundry coke was at low ebb all through the year.

Railroads advanced rates on coal to most points during the year, but corresponding advances were made in all competing fields, so no loss of business to the mines of the State resulted, except perhaps to points where Alabama coal was in competition with water-carriage rates out of Pittsburgh, such as New Orleans.

During the last 3 weeks of the year it became evident that there is actually little idle labor in the State available for the coal mines, and if outputs are to be increased very much, the question of labor supply may become a serious one. The same state of affairs exists with respect to

[1] H. S. Geismer, *Coal Age*, Jan. 8, 1916, p. 38.

railroad-car supply, and the railroads would have difficulty in handling a larger tonnage with their present equipment.

Arkansas.[1]—The production of coal in Arkansas for the year ending June 30, 1915, was 1,700,099 short tons, valued at the mines at $3,137,211, as against 2,136,783 short tons for the fiscal year ending June 30, 1914, valued at $3,531,100, showing a decrease in tonnage of 436,684 short tons and a decrease in value of $393,889.

This falling off in the production of Arkansas coal was due to several causes, the most important factor being cheap oil and gas in Texas, Oklahoma and Louisiana. Owing to the cheapness of gas compared with coal for domestic use and the fact that gas is an ideal fuel, it has almost entirely displaced coal in the local markets, and there has been a great decrease in the use of Arkansas coal for domestic consumption.

There were employed in and around the mines for the year ending June 30, 1915, 4228 persons, compared with 5356 in 1914, showing a decrease of 1128. The greater part of these men are still idle and unable to obtain work. Some of the oldest miners have moved to other coal fields in search of employment. However, conditions begin to look brighter, several old mines have been re-opened and quite a number of small operations have been started by coöperative companies composed of miners who have long been idle.

At this time there are 141 mines being operated, including the small mines mentioned, 77 slopes, 50 shafts, 13 drifts and 1 strip pit. The mines employ 2552 miners, 1387 company men and 289 office men and mine officials. The average quantity of coal produced by each man employed, exclusive of company men, office men and mine officials, was 666.18 tons. The miners used 67,545 kegs of black powder, at a cost to them of $135,090. There are 346 mules working underground, while five mines use electric motor haulage.

A favorable aspect of the coal situation in Arkansas was the decrease in the quantity and percentage of coal shot off the solid. The production of the following companies which use electric coal-mining machines was: Central Coal and Coke Co. mine No. 6, Huntington, Sebastian County, 188,316 tons; mine No. 4, Hartford, Sebastian County, 139,457 tons; Bolen Darnall Coal Co., mine No. 2, Hartford, 51,027 tons, making a total of 378,800 tons.

Colorado.[2]—The coal industry of Colorado at the close of the year 1915 showed an upward trend. After a period of dull business caused by the recent labor troubles and the general stagnation of other industries, the tide has turned and the coal markets are opening up and a large number of miners are back on the payrolls. Were it not for a car short-

[1] Thomas H. Shaw, *Coal Age*, Jan. 8, 1916, p. 39.
[2] A. R. Tibbits, *Coal Age*, Jan. 8, 1916, p. 40.

age that is holding up coal shipments, there would have been a material increase in the State's output. A mild fall and winter have further handicapped the sale of coal.

The increase of 450,000 tons of coal for the year 1915 over that of 1914 demonstrates beyond question that notwithstanding all the above factors the industry is fast resuming normal conditions.

Many operators have made a vigorous campaign to improve the safety and sanitary conditions of the mines, and the result is that the death rate has been materially reduced. There is a marked improvement in the relations between employers and employees, many of the striking miners have been put back to work and as fast as there is work for them, this number will be increased.

The Colorado Fuel and Iron Co. occupies a leading position in the general effort to improve conditions, and it is confidently expected that in the near future all the miners who lost their places in consequence of the strike will be reinstated.

A great work is being done to improve the sociological condition of the State's coal camps. This is especially true of the Colorado Fuel and Iron Co., which is making every effort to secure in its various coal camps not only sanitary surroundings, but also an improvement in the general living conditions. There were no labor troubles during the year and no increase or decrease in the wage scale or the price of coal. In most coal camps it is not obligatory to trade in the company stores.

An industrial board was established and a compensation law enacted by the last legislature. The industrial board is empowered to investigate alleged unfairness in the various industries and to adjust them. The authority of this board is far reaching and will show good results.

The future of the coal industry of this State is promising. Colorado is rich in coal and is surrounded by a vast territory needing fuel. With labor satisfied and equitable railroad rates there is no reason why the annual output should not reach the 20-million-ton mark.

The following is a statement of the output and men employed during the year:

Total production, 1914	8,170,559
Increase, 1915	454,421
Average number men employed	12,677
Total number of days worked	168

Illinois.[1]—Material advancement in the Illinois coal industry was made during the year by the formation of several organizations in major-producing districts to maintain production more in accordance with market demands and to furnish statistical information as to costs and selling prices. Progress has been effected in uniform costs, accounting

[1] Abstracted from *Coal Age*, Jan. 8, 1916, p. 41.

for mine and retail yards, uniform sizing of the mine output, standardization of sales contracts and restriction of production.

A very noticeable change is the general disposition of operators and mine owners to favor coöperative measures. Concrete results in stabilizing selling conditions have already been achieved, and operators look forward with confidence to still further improvement along these lines. Freight disturbances have been acute. The general Western rate advance decision added 10 cts. to the price of coal in the larger portion of the Southern and Western country served by Illinois mines in competition with docks and Southern coal. A proposed advance of 5 cts. per ton for intrastate business has been blocked thus far.

Readjustments of freight rates have as a rule been diametrically opposed to the interests of Illinois shippers. Illinois domestic- and steam-coal markets for the first 4 months of the year were in a bad way. Domestic demand was negligible during the summer months, and steam business showed only slight improvement during the late summer and early fall. From October to December, however, there was a real betterment in the steam trade, which improvement was most pronounced in the fine coals, which showed a higher range of prices than ever before at the same time of year. There was at the end of the year a growing scarcity of tonnage.

Domestic coal requirements also broadened in the last 3 months of the year. Prices were well supported, notwithstanding a mild and open winter. Reduced quantities of free coal have been consigned to Western distributing centers as compared with previous years. An accumulated tonnage has been held at the mines, waiting for a proper price rather than having to dump it into markets at a sacrifice. As a whole, Illinois coals have fluctuated less in price this year than previously. Mine labor has been plentiful until recently, and car supply has been unimpaired.

Indiana.[1]—The condition of the coal-mining industry in this State during the fiscal year ending Sept. 30, 1915, was much better than had been expected. During the first 7 months there were 25 less mines in operation than during the latter part of 1914, owing to the general business depression and the ruinous competition from which the coal business has suffered for years in this State.

There were eight mines abandoned during the fiscal year, and many were closed temporarily, as the small demand would not justify the expense of keeping the mines opened. Of those operating, few were working full time, and the majority were in operation less than half time. As a result of these conditions, many miners were out of employment, and mine property in many instances was allowed to depreciate. How-

[1] Michael Scollard, *Coal Age*, Jan. 8, p. 41.

ever, about the middle of July, 1915, conditions grew much better and have continued to improve since.

Notwithstanding the time lost during the summer months on account of no demand for coal, a number of local strikes and some shortage of railroad cars in the southern part of the State, the total production of mines employing 10 or more men was 15,346,921 short tons. The estimated production of mines employing less than 10 men was 350,000 tons, making a total output of 15,696,921 short tons. The wages paid to miners was $13,420,071.78. This does not include wages paid in small mines throughout the State.

The average number of miners employed during the year was 20,702. Of the total production of coal 96,567 short tons was from the Block seam. The production of block coal is steadily decreasing, and at the present time this grade of fuel is consumed principally in this State.

Owing to a stagnated condition of the coal market, operators who could work their mines at a profit were considered fortunate. It is difficult to ascertain just exactly what the average selling price of coal was during the past year, but it is the consensus of opinion that the average price of No. 4 and No. 5 mine-run varied from $1 to $1.15 per ton, f.o.b. at the mine. With demand for coal steadily increasing, the operators agreed on a system of reporting their sales and prices with a view to getting a uniform price for their production, and the future looks brighter.

The total consumption of coal in this State was 9,297,723, tons, while 6,049,198 tons was shipped to other States. Of the production sold outside of the State, the major part went to Illinois, principally the Chicago market.

Within the past 2 years steam shovels have been introduced into this State, and during the fiscal year ending Sept. 30, 1915, extensive work has been done in stripping coal. At present there are several large steam shovels which are operating practically all the time. There are two or three stripping mines that are removing 25 ft. of overlying strata and have a capacity of 250 tons of coal per day.

During the year 52 fatal accidents occurred. The production per fatality was 295,133 tons. Two deplorable accidents resulted from falls of slate, one at Speedwell No. 2 mine, operated by the Lower Vein Coal Co., of Terre Haute, and the other at the Ayrshire No. 7 mine, operated by the Ayrshire Coal Co., of Oakland City.

Iowa.[1]—Of late years there has been but little change in the conditions of the Iowa coal industry. Probably this is owing to the many mines in the neighboring State, Illinois, which have to look largely west-

[1] L. E. Stamm, *Coal Age*, Jan. 8, 1916, p. 42.

ward for the sale of their output. Within the last few years a great deal of Illinois coal has been shipped into Iowa, the Dakotas and Nebraska.

Freight rates have been in favor of the Illinois producer and have enabled him to get into territory that was formerly held by the Iowa coal operator. Also within the past few years Colorado and Wyoming have been mining and shipping coal into the Dakotas and Nebraska. This has put Iowa between two active coal fields, with the result that not much increase has been made in the tonnage produced by the Iowa mines for some years. This is not because of the inferior quality of Iowa coal, for the fuel is a high-grade bituminous that burns and stocks well.

The growth in the coal industry, however, has been a healthy one. Between two and three hundred mines are in operation and notwithstanding adverse freight rates and keen competition, they are in better condition to-day than they have been for some years. Better equipment is being used than formerly, a number of mines having been recently equipped with electric hoists and electric haulage, as well as cutting machines.

The production for 1915 will approximate 7,500,000 short tons and show something like 16,000 men employed in the industry.

Few complaints have been registered this fall regarding a car shortage though October saw some trouble in this respect with a few companies.

Few labor troubles occur in the coal-mining industry of Iowa. Those that do are local and are usually settled by the district and State officers of the miners and operators without stopping work at the mines. Two years ago the miners in this State kept at work while their representatives and those of the companies were perfecting a new wage agreement.

The outlook for increased coal production in this State for 1916 appears good. Much prospecting has been done in Hardin County, and it is quite likely that considerable coal development will be made in that locality this coming year. While Mine No. 10 of the Phillips Coal Co. in Dallas County has suspended operations for a time, the loss in this county will be more than offset by the production of the new Dallas Coal Co.

Kansas.[1]—During the fiscal year ending June 30, 1915, there was 6,701,426 tons of coal produced in the State of Kansas. The production by counties was as follows: Crawford, 4,631,236 tons; Cherokee, 1,784,637; Leavenworth, 184,226; Osage, 78,827; Linn, 18,000; Franklin, 2500; Bourbon, 2000.

There were 27 fatal accidents in and around the Kansas mines,

[1] John Pellegrino, *Coal Age*, Jan. 8, 1916, p. 43.

making one fatal accident for every 247,831 tons of coal produced. There were 716 non-fatal accidents during this year, or an average of one for every 9359 tons of coal produced.

The coal production of the State has decreased slightly because of labor troubles and the companies shutting down part of their mines on account of not having a market for their coal.

Strip mining by steam shovels in Kansas is also affecting the deep mining to a great extent. Crawford County produced 421,348 tons of strip coal and Cherokee County 195,287 tons during the fiscal year ending June 30, 1915, making a total of 616,635 tons of this fuel. The production of strip coal was increased during the year in the two counties by 232,780 tons, which is 9767 tons more than Crawford County alone produced in the previous year. At present there are 22 steam shovels in the State and each averaged 28,030 tons of coal during the year.

Shotfiring by electricity is progressing favorably. Three mines are daily using a mechanical device to fire their shots.

First-aid and rescue work in Kansas are yet in their infancy, and there is only a small supply of rescue apparatus around the mines. The State has a mine-rescue station at West Fourth St., Pittsburg, Kan., and rescue car No. 4 of the United States Bureau of Mines has the supervision over it.

Kentucky.[1]—The coal production of this State for 1915 will be about 21,375,000 tons, of which the eastern portion produced a little over 14,500,000 tons. Though these figures show a gain over the preceding year, business as a whole fell much below expectations.

At the beginning of the year a general depression was experienced throughout the State, owing to the European war, but the latter part of the year showed an improved demand permitting the mines to work more steadily.

The Big Sandy and Tug Fork districts in the eastern part of the State were affected by car and labor shortage, and though the production from these districts showed an increase of over 1,000,000 tons, it was less than it would have been had there been plenty of cars and enough labor.

The coke production in the southeastern part of Kentucky was good and showed a marked increase in the latter months of the year which offset the decrease in the spring. The net increase exceeded 1,000,000 tons.

The general outlook in the eastern field is very bright. The principal gains in production were made in Harlan, Letcher and Perry Counties,

[1] C. J. Norwood, *Coal Age*, Jan. 8, 1916, p. 43.

distributed as follows: Harlan, 20 per cent.; Letcher, 60 per cent.; Perry, 90 per cent.

Unsatisfactory conditions prevailed in the western part of the State. From the present outlook there will be a decrease of about 950,000 tons. The causes for this are said to be the depression in the cotton market and also in the manufacturing plants in the South, the introduction of fuel-economizing locomotives by railroads using western Kentucky coal and the mild weather that prevailed throughout the year. The high cost of production and the increased freight rates to the South are also said to be factors in the low production.

New Mexico.[1]—The gross coal production of New Mexico for the year ending Oct. 31, 1915, amounted to 3,858,554 tons, of which 3,061,379 tons were bituminous, and the balance sub-bituminous and anthracite. The gross production exceeded that for the previous year by 31,669 tons. Eight new mines were started during the year, and the total number in operation was 63. The coke production amounted to 364,873 tons, valued at $1,199,776. There were 21 fatal accidents during the year, and 185 non-fatal.

North Dakota.[2]—The production of lignite coal during the year 1915 is estimated as being close to 600,000 tons, a greater amount by 50,000 tons than has been mined in any year heretofore. The output has doubled in the last 7 years, only a little over 300,000 tons being mined in 1908.

One hundred and twenty mines have been in operation, varying in size from very small ones employing but three or four men to large operations employing 400 men. The total number of men engaged has averaged over 850 during the 6 winter months and 460 during the summer months.

Maryland.[3]—The coal production of Maryland was somewhat larger for 1915 than for 1914, when it was below the 4-million-ton mark. There were several coal mines idle during the greater part of the year. Some of these are good producers, and from the best information available a great many will report a decrease, as the demand for coal was not large. Not only was there a decrease in many localities in the amount of coal mined, but prices were not at all satisfactory.

The Consolidation Coal Co. will report a large increase, as its mines worked full time during the entire year, producing about 2,040,000 tons. The number of employees in the mines of the State will not be materially changed from that of the year 1914, which was about 5775.

[1] Rees H. Beddow, *Coal Age*, Jan. 8, 1916, p. 45.
[2] Jay W. Bliss, *Coal Age*, Jan. 8, 1916, p. 45.
[3] William Walters, *Coal Age*, Jan. 8, 1916, p. 44.

Michigan.[1]—The estimated tonnage of Michigan for 1915 will be about the same as that for last year—1,250,000 tons—with the indications at the present time for a much greater tonnage in 1916.

There were no labor troubles in the State during the year, and there was a full car supply during 1915.

Missouri.[2]—The coal production in Missouri for 1915 will be about 4,000,000 tons. About one-half of the coal that is mined in the State of Missouri is "powder mined," while approximately 1,000,000 tons are produced by hand.

Since the discovery of coal, about 1806, this State has produced nearly 125,000,000 tons, and at the present rate of consumption it is figured that there is enough coal to last 9000 years. The banner year for production was in 1905, there being 4,381,956 tons mined, valued at $7,147,665.

Much interest is being taken in the coal industry, and every effort is made for the improvement of the work and for the safety of those employed. The labor troubles in 1915 were of little consequence.

Montana.[3]—The coal industry of the State of Montana for the year 1915 has not been all it might have been. This was partly because the railroads were not operating to their full capacity and the winter of 1914–15 being mild, the demand for coal in the commercial market was not particularly good.

The railroad mines of the State, which include those of the Republic Coal Co., of Klein, Musselshell County, owned by the Chicago, Milwaukee and St. Paul Railroad Co., those of the Northwestern Improvement Co., of Red Lodge, Carbon County, owned by the Northern Pacific Railroad Co., and those of the Cottonwood Coal Co., of Stockett, Cascade County, owned by the Great Northern Railroad Co., consume their own product.

The year 1914 showed a decrease in tonnage of 427,000 below the 1913 output, and the output for 1915 will be below that of 1914.

There are various causes for these conditions, one being that the winters of 1913–14 and 1914–15 were very mild, another being that a great many industries of the State are adopting the use of electricity, all of which has a tendency to curtail the coal consumption.

Ohio.[4]—At the beginning of 1915 prospects were not bright for a very decided increase in the coal production over that of the previous year, when the tonnage decreased over one-half of the normal tonnage reported for the year 1913, the total tonnage for which amounted to 36,285,468 tons, as compared with 18,843,115 tons reported for the year 1914.

The financial and industrial condition of the entire country was

[1] Thomas Kanary, *Coal Age*, Jan. 8, 1916, p. 44.
[2] J. P. Hawkins, *Coal Age*, Jan. 8, 1916, p. 44.
[3] John Sanderson, *Coal Age*, Jan. 8, 1916, p. 44.
[4] J. M. Roan, *Coal Age*, Jan. 8, 1916, p. 45.

responsible in a measure for the depression in the coal industry for the first half of 1915. The protracted suspension of the mines located in Belmont, Harrison and Jefferson Counties continued through 1915, until a satisfactory wage-scale agreement was entered into between the operators and representatives of the United Mine Workers at Cleveland, Ohio, May 11, 1915. However, the trade even at this time did not justify the resumption of many of the large mines, and some remain suspended at the close of the year. After a long suspension, such as was experienced in this district for 18 months, it requires from 60 to 90 days for mines to be placed in condition to produce anything like normal output.

Practically the same conditions prevailed in the Hocking Valley district, composed of Athens, Hocking and Perry Counties, when in July, a number of large mines suspended operations and have been idle since. Inability to produce coal in competition, on account of local mining conditions in general, but principally the railroad rate now in operation in that district, is held responsible for the wholesale closing of so many of the large operations in this locality.

Never in years were mining conditions in this section of the State so acute. Over 5000 men were suddenly thrown out of employment, and want and suffering were felt for several months. The situation became so serious that State aid was solicited, and the work of collecting and distributing supplies was done in a systematic manner through the agency of the office of the adjutant general of the State with the aid of a corps of able assistants. The industrial commission, through the mining department and the department in charge of the free employment bureaus of the State, was also called upon to assist in securing employment for the miners who were without means of obtaining a livelihood and who were in an absolute state of want.

With conditions in the different mining districts of the State assuming somewhat near the normal condition, the outlook for the year 1916 is promising for the coal trade, and the tonnage will undoubtedly be much higher than that reported for the years 1914 and 1915.

On April 12, 1915, a mining scale was signed at Coshocton, Ohio, by representatives of the miners and operators of that district, the mines of which had been idle since Apr. 1, 1914, when the wage agreement between the miners and operators expired.

On May 11, 1915, another wage-scale agreement was signed between the representatives of the miners and operators of the eastern Ohio district at Cleveland, Ohio. This ended a suspension of the mines in that district that had existed for a period of 18 months.

The signing of these two wage agreements ended two of the most protracted suspensions of mining districts which the State had experienced in years and was due largely to the enactment of a law in February, 1914, which changed the system of weighing the coal and the method of paying for it.

Advance reports received from the various mining districts indicate a decrease in the tonnage of the Counties of Athens, Hocking and Perry. The mines of Belmont, Harrison and Jefferson Counties will report increases as compared with the tonnage for the year 1914. Other mining districts of minor importance as regards production will also show increases.

The number of persons employed in the State for the year will probably show a decrease, due to the suspensions in two of the largest coal-producing districts in the State for at least half of the year. There was no great demand for labor after these mines opened up in June and July, and a great many of the miners sought employment in other localities. The same holds true of the Hocking Valley district, where over 5000 men were out of employment for several months the latter part of the year, some of whom sought other employment. The close of the year finds 2000 men still out of work in this district.

On an average the mines of the State worked only about one-half time. Especially in the districts already mentioned, reports may indicate that they did not even average half time. The mines of the Guernsey or Cambridge district operated practically the entire year, but not nearly full time, some of the mines working only a few days of each month, until the fall and winter months, when they averaged nearly full time.

There was very little Lake trade reported from the Hocking Valley district for the year. In eastern Ohio the mines were so late starting operations that there was little Lake business, and shipments were slow when the mines did resume operations. The Lake trade from the Cambridge district was about 60 per cent. of the normal.

The car supply in the Hocking Valley district was equal to the demand, owing to so many of the large mines being idle a greater portion of the year. In eastern Ohio, when the coal trade became more brisk, there was a shortage at nearly all of the mines. In the Massillon district frequent complaints of a shortage in the car supply were made, especially at the mines located on the Baltimore & Ohio R.R.

For the year ending Dec. 22, 1915, 60 fatal accidents were reported to the mining department; in addition to this, two accidents which occurred in 1914 terminated fatally in 1915.

Falls of roof were responsible for 30 deaths; falls of coal, 6; mine-cars, 10; motors, 4; mining machines, 2; electricity, 4; shot blowing through the rib, 1; returning too soon to an unfired shot, 2; and to miscellaneous causes, 1. In 1914, 58 fatalities were reported. Falls of roof show a decrease of 9, falls of coal an increase of 3, mine-cars 3 and electricity an increase of 3.

Oklahoma.[1]—In the year ended June 30, 1915, 3,321,795 tons of coal was produced from the mines of Oklahoma; a decrease from the previous year of 410,757 tons. Of the 1915 output 2,551,041 tons was obtained by pick mining, while 770,754 tons was from machine mines. This is an increase of machine-mined coal of 82,064 tons, or 2.5 per cent. over the production for the fiscal year 1913–14. The machine-mined coal now constitutes 23.2 per cent. of the total coal output.

Reports were received from 80 mines, of which 39 showed a production of 30,000 or more tons per annum. There were 19 mines with an average daily output of over 300 tons. The largest average daily production is 771 tons and is reported from the Rock Island No. 40 mine.

The work at the mines was more intermittent than usual. The average miner in the pick mines of district No. 1 received the steadiest employment—194 working days per year—while his fellow miner in operations of the same character in district No. 3 secured but 148 days of work.

As in previous years, Pittsburgh is the leading coal-producing county, but Latimer, Okmulgee and Coal Counties follow closely in order.

Haskell County produced no coal last year, as the Sans Bois mines at McCurtain were idle. These mines, however, are being put in shape to operate, and this county will undoubtedly show a considerable production at the end of the next fiscal year. The major portion of the machine-mined coal was produced from the flat Henryetta seam. In many of the mines of the McAlester field the extremely heavy pitch makes the use of machines almost impossible under the present system of mining, and consequently most of the coal is still obtained by pick mining. However, as the mines become deeper, the pitch usually becomes flatter, and in these cases machines are gradually being introduced where practicable.

Oregon.[2]—Though the mining of coal in Oregon has never been considered one of the important industries of the State, nevertheless in the last 6 years alone 340,728 tons has been mined, having a total value of $946,903. The statistics of the coal production for 1915 are not as yet available, but in 1914 there was 51,558 short tons mined with a value of $143,556. This is a slight increase over the production in 1913, which was 46,063 short tons, valued at $116,724.

All the coal mined in Oregon comes from the Coos Bay coal field, so named from the fact that it entirely surrounds that body of water.

[1] Edward Boyle, *Coal Age*, Jan. 8, 1916, p. 48.
[2] Henry M. Parks, *Coal Age*, Jan. 8, 1916, p. 49.

This field occupies a total area of about 230 sq. miles. The two largest producing mines are those operated by the Beaver Hill Coal Co. and the Coos Bay Coal and Fuel Co. In 1914 the average number of workmen at the Beaver Hill was 77 and at the Coos Bay Coal and Fuel Co.'s mine 62.

Pennsylvania.[1]—The total production of coal in Pennsylvania for the year 1915 amounted to 246,950,197 tons. Of this amount 88,995,061 tons was anthracite and 157,996,137 tons bituminous. The amount of coal consumed about the mines in the anthracite region is estimated at 9,000,000 tons and in the bituminous region at 7,000,000 tons.

The number of employees in the anthracite region was 168,000 and in the bituminous region 180,000. Fatal accidents in the anthracite region numbered 571 and non-fatal accidents 957. In the bituminous districts there were 428 fatal and 1257 non-fatal accidents. The coke production in the bituminous region amounted to 18,000,000 tons. No coke was produced in the anthracite region. The estimates of production in 1915 by districts are as follows:

ESTIMATES OF BITUMINOUS AND ANTHRACITE PRODUCTION AND PERSONS EMPLOYED IN MINES DURING 1915

	Bituminous.			Anthracite.		
Districts.	Production (Net Tons).	Employees, Inside.	Employees, Outside.	Production (Net Tons).	Employees, Inside.	Employees, Outside.
First	3,683,574	5,000	75,236	1,022,626	2,207	121,377
Second	6,800,000	6,900	220,000	4,005,926	8,733	384,162
Third	3,000,000	5,500	170,000	3,729,104	7,860	263,126
Fourth	5,400,000	7,300	160,000	3,584,000	6,000	280,000
Fifth	5,800,000	6,900	185,000	3,198,245	6,940	280,738
Sixth	4,400,000	6,320	103,080	6,048,000	13,150	582,400
Seventh	4,000,000	5,450	109,000	6,139,840	11,500	612,640
Eighth	4,000,000	6,000	72,870	3,975,424	8,500	504,000
Ninth	6,000,000	7,450	3,500,000	5,990,000	10,019	493,844
Tenth	3,300,000	5,800	85,000	5,768,000	10,750	470,400
Eleventh	7,739,191	6,075	309,567	6,720,000	11,862	750,521
Twelfth	4,240,000	6,250	261,850	3,553,473	7,009	474,982
Thirteenth	4,000,000	5,150	45,000	3,035,110	6,879	350,879
Fourteenth	5,500,000	5,750	68,000	3,080,000	6,500	593,600
Fifteenth	5,000,000	6,500	120,000	2,594,700	6,717	385,814
Sixteenth	6,500,000	7,500	500,000	3,205,780	7,468	392,612
Seventeenth	4,261,394	7,220	63,598	5,271,280	9,234	552,720
Eighteenth	4,000,000	6,700	72,500	3,475,321	6,100	337,321
Nineteenth	6,630,000	6,400	185,000	3,584,000	7,700	537,600
Twentieth	5,500,000	5,500	115,000	2,486,400	6,000	470,000
Twenty-first	6,560,340	5,860	175,369	3,184,365	6,896	310,831
Twenty-second	4,750,000	5,000	70,000	....	....	....
Twenty-third	5,700,000	6,600	140,000	....	....	....
Twenty-fourth	4,874,412	6,288	100,763	....	....	....
Twenty-fifth	4,500,000	6,500	150,000	....	....	....
Twenty-sixth	3,783,538	5,304	86,830	....	....	....
Twenty-seventh	4,151,700	5,308	93,000	....	....	....
Twenty-eighth	4,857,498	6,150	23,000	....	....	....
Twenty-ninth	4,002,505	4,617	103,605	....	....	....
Thirtieth	5,062,095	5,900	170,996	....	....	....
Totals	14,996,247	183,192	7,534,264	83,616,484	168,019	9,149,467

[1] Frank Hall, *Coal Age*, Jan. 8, 1916, p. 49.

Operations in both regions were somewhat curtailed by the shortage in the labor and car supply. The question of labor is a serious one at the present time, largely because the European war has made a great drain on the number of foreign miners. In both the anthracite and the bituminous regions the Slavs constitute a majority of the mine workers.

In the anthracite region there are at least 75,000 Slavs, 12,000 Italians, 11,000 Irish, 10,000 Austro-Hungarians, 7000 Welsh, 4000 Germans, 6000 English and 50,000 of other nationalities. In the bituminous region there were 58,000 Slavs, 29,000 Italians, 2000 Irish, 23,000 Austro-Hungarians, 4000 Germans, 5000 English and 65,000 of other nationalities. Miners representing 30 different nationalities are employed in the coal mines of the State.

Anything that interferes with this foreign labor is keenly felt by the coal operators, and as most of the nations represented in the foregoing enumeration are at war, many of the miners have been called to the service. The effect of the exodus is decidedly detrimental to the mining industry.

Aside from the scarcity of labor caused by the unusual conditions existing at the present time, there is a gradual but steady diminution in the ranks of the first-class miners. The Welsh and English are growing fewer, and the French have become almost a negligible quantity. The Irish, once prominent, are giving way to the Slavs and seeking more congenial fields of labor.

The coke trade, active and profitable at the close of the year, is still criticised for its wasteful methods of production. Valuable by-products, such as tar, ammonia, gas and benzol, are to a great extent wasted by the use of the beehive oven. Millions of dollars might be saved annually by careful scientific methods, such as are in vogue in Germany.

The year records three serious disasters, all due to explosions of gas, but nothing of an extraordinary character. One occurred at the Prospect Hill colliery of the Lehigh Valley Coal Co. on Feb. 17, by which 13 men were killed; one at the Orenda No. 2 mine of the Orenda Coal Co., Aug. 31, in which 19 men were killed; and the third at the Smokeless No. 1 mine of the Smokeless Coal Co., May 24, which killed 9 men.

Two breakers in the anthracite region were destroyed by fire—one at Jeddo, Jan. 15, belonging to the G. B. Markle Co., and the other at Cranberry, May 25, belonging to Pardee Brothers & Co. The loss entailed in these fires amounted to several hundred thousand dollars.

One of the important events of the year was the declaring unconstitutional of the anthracite coal tax by the Supreme Court, an action that will result in the loss of $5,000,000 taxes annually to the State.

A marked advance in safety measures and improvements in the living and social conditions in the mining communities was made during the year. The efforts put forth by many of the operators to give to their employees the greatest possible protection have led them in their zeal to exceed in some instances the provisions of the mining laws. It seems to be recognized as a fact that preventive measures, even if costly to install or adopt, are a good investment. Making all due allowance for the high humanitarian spirit and genuine brotherly regard that impel men to protect their employees, the practical wisdom of taking all possible precautions to avoid accidents is fully understood by the intelligent coal and coke operators of to-day.

Bituminous coal at the close of the year shows an increase of more than 100 per cent. in price on prompt coal, with a heavy demand. The regrettable lack of facilities in the way of water transportation has made it necessary to stop the shipment of coal to many points in the East, with the result that the territory including New York and New England is suffering acutely.

Tennessee.[1]—The coal production of Tennessee for the year 1915 was 5,730,361 short tons. The small output is attributed to general business depression, the large number of factories that have changed from steam to electric power, the inability of our mines to secure large contracts for steam coal and also to the considerable number of mines recently opened up in southern and eastern Kentucky and in southwestern Virginia.

Only a few mines in this State have been able to handle or dispose of the steam coal produced. Some of them have been running about half the time on short orders, the average sale price for steam coal being about $1.10 per ton.

The market for steam coal from this section was exceedingly dull and discouraging until the first of November. Since that time there has been an increased demand, but the car shortage is practically confining the production to the average obtained during the summer and fall months, although slightly increased prices are being realized.

The demand for domestic coal has been good, and could the operators have disposed of the steam product at a fair price, this would have been a fairly good year, instead of one of the most discouraging periods in the history of the State. The average price of the best domestic coals for this year was $1.95 per ton.

Utah.[2]—The total coal production of Utah was practically the same as that of last year, 3,108,715 being produced during 1915—an inerease of

[1] R. A. Shiflett, *Coal Age*, Jan. 8, 1916, p. 51.
[2] J. E. Pettit, *Coal Age*, Jan. 8, 1916, p. 52.

5,679 tons. The production of coke amounted to 357,572 tons—an increase of 8776 tons over last year.

There were no labor troubles during the past year, and the car situation was 64 per cent. normal. During August, September and October there were 4044 men employed in the coal-mining industry. There were 11 fatal, 28 serious and 155 non-serious accidents.

New producing mines were opened during the year. The average number of working days was 202. The selling price was the same as last year, but the prospects look brighter for the coming 12 months.

Washington.[1]—The production of coal in 1915 fell far short of that in the previous year. This was due principally to the cheapness of fuel oil, which has been substituted for coal on the railroads and steamers engaged in local and coastwise traffic. The output for the year was 2,429,095 short tons, a decrease of over 535,000 tons as compared with 1914.

The past year has been one of the dullest that the coal business in the State has experienced. The outlook for 1916 is better, but it is not expected that there will be any great improvement until the railroads find it more economical to use coal than fuel oil.

The production of coke in 1915 showed an increase over that in the previous year and amounted to 136,552 short tons as compared with 78,573 short tons during 1914. All the coke produced in the State comes from Pierce County. The production has been steadily increasing during the past few years and from present indications will assume still larger proportions. Most of the output is consumed by smelting companies in the Pacific Northwest.

No labor troubles occurred during the year, as the operators and miners are on very friendly terms and have experienced no difficulty in settling any differences that arose during the season.

Forty-five fatal accidents had occurred up to Dec. 20, against 17 for the previous year. Thirty-one men were killed by an explosion which occurred at the Ravensdale Mine, Ravensdale, Wash., on Nov. 16.

West Virginia.[2]—The data taken from the records of the Department of Mines of West Virginia for the year ending June 30, 1915, show a total production of 64,118,677 long tons, or 71,812,918 net tons, a decrease from the 1914 figures of 1,664,411 long tons. This decrease was due to the general depression in the coal business during the first 6 months of the fiscal year. During the last 6 months the demand for West Virginia fuel increased, especially for the soft coal of the Pocahontas and New

[1] James Bagley, *Coal Age*, Jan. 8, 1916, p. 52.
[2] Earl A. Henry, *Coal Age*, Jan. 8, 1916, p. 52.

River fields, to the extent that the former had the largest production of any period in its history.

The accompanying table shows the statistics of coal and coke production, as well as those of the fatal accidents and the nationalities of the employees.

COMPARATIVE STATEMENT OF COAL PRODUCTION FOR FISCAL YEARS 1915 AND 1914, TONS OF 2240 LB.

County.	1915.	1914.	County.	1915.	1914.
Barbour	962,228	1,098,495	Mineral	556,350	688,172
Boone	575,835	472,933	Mingo	2,538,174	2,510,568
Braxton	294,206	265,101	Monongalia	319,947	400,046
Brooke	727,326	564,337	Nicholas	122,264	96,440
Clay	531,645	396,411	Ohio	540,333	482,844
Fayette	7,881,872	8,686,988	Preston	980,322	1,281,181
Gilmer	137,971	88,369	Putnam	479,045	554,923
Grant	165,121	189,746	Raleigh	4,957,567	5,066,221
Greenbrier	24,128	22,633	Randolph	550,108	737,718
Harrison	4,533,032	5,097,644	Taylor	946,814	1,068,772
Kanawha	5,142,586	5,108,783	Tucker	1,453,752	1,199,113
Lewis	300	28,956	Upshur	98,504	97,473
Lincoln	41,966	61,588	Wayne	51,458	55,060
Logan	6,307,286	5,333,943	Wyoming	96,166	39,789
Marion	5,988,879	5,830,070			
Marshall	963,173	929,425	Totals	63,818,677	65,483,088
Mason	125,135	123,630	Small country mines	300,000	300,000
McDowell	13,007,674	14,055,157			
Mercer	2,717,510	2,850,499	Grand totals	64,118,677	65,783,088

Total tonnage, gross tons	64,118,677	Number of fatal accidents, inside	455
Total tonnage, net tons	71,812,918	Number of fatal accidents, outside	31
Decrease, gross tons	1,664,411	Decrease in fatal accidents	86
Total coke, net tons	1,103,004	Number of Americans employed	49,963
Decrease, net tons	854,397	Number of foreigners employed	31,365
Tons per fatal accident, gross tons	140,920	Total number of employees	81,328

While development has not been as pronounced as that of the previous year, there have been several new operations started throughout the State, especially in Raleigh, Logan and Boone Counties. It is worthy of note that no labor troubles occurred during the year, and had it not been for the depression in the coal business, there would have been a large increase over previous years. There is sufficient development to produce a hundred million net tons of coal were the railroads provided with the proper facilities to handle this large tonnage. As 90 per cent. of the coal produced in the State passes beyond its boundaries, the prosperity of the coal industry depends entirely upon the transportation facilities of the different railroads.

A large number of coal companies throughout the State have been at great expense improving the sanitary and safety conditions of their mines, and it is the general opinion of the operators that the increased freight rates advocated by some of the railroads would seriously injure the coal business to the extent that there would be a large decrease in the production. Such an increase in rates would no doubt put many mines out of business.

Wyoming (District No. 2).[1]—The fiscal year ending Sept. 30, 1915, has not been one of business prosperity for the coal industry of Inspection District No. 2, which comprises the northern part of Wyoming. There are 10 large companies operating in this district, whose production for the year was 1,808,820 tons of coal, or a decrease of 275,108 tons under the previous year.

The greatest decrease occurred in the Sheridan coal field of Sheridan County, the coal being a high-grade lignite used mostly for commercial purposes.

The Cambria Fuel Co., operating mines in Weston County in a bituminous bed of coal that is used almost entirely by the Burlington R.R. for steam purposes, fell short 50,269 tons of its 1914 production.

The Big Horn Collieries Co., operating mines in Hot Springs County, the coal being of a semibituminous nature and a splendid steam fuel, produced 64,897 tons over the previous year, possibly due to better railroad accommodations such as follow an increase in population.

There were employed in the industry 2016 men for an average of 163 working days in the year for each mine, which means that some of the mines worked less than one-third time. There were no labor troubles, and labor was plentiful.

There were only 3 fatal and 37 non-fatal accidents reported, the compensation law now making it possible to obtain a complete record of all accidents.

It is safe to say that the coal mines are under the management and supervision of as competent mining men as there are in the mining industry. The most up-to-date machinery and safety appliances are in use, and every precaution is taken to protect life and property.

(District No. 1[2]).—The annual coal production of District No. 1, Wyoming, shows a decrease for the fiscal year ending Sept. 30, 1915, from the production of the preceding 12 months. There seems to have been a general depression in all wage-labor industries, and coal mining was no exception.

There was also a decrease in the fatal accidents during the past year, there being 18 reported against 43 during 1914. The Superior Coal Co. mined about 1,250,000 tons of coal without a fatal accident. I do not believe that this splendid record is a mere coincidence or piece of luck, but one of the good results from close supervision over the working faces and from the efforts of the management in charge to maintain strict discipline in and around the mines.

The following are the chief results for the year:

[1] Geo. M. Aiken, *Coal Age*, Jan. 8, 1916, p. 54.
[2] Geo. Blacker, *Coal Age*, Jan. 8, 1916, p. 55.

Counties producing coal	4	Boys aboveground	27
Shipping mines	34	Others aboveground	627
Local mines	5	Total employees	5,363
Number of miners	3,292	Tons of coal produced	4,460,169
Other underground men	1,377	Days of active operation	174
Boys underground	40	Kegs of powder used	49,337

THE WORLD'S PRODUCTION OF COAL, IN SHORT TONS

Country.	1911.	1912.	1913.	1914.	1915.
United States	496,371,126	534,466,580	569,960,219	513,525,477	517,371,921
Great Britain	304,518,927	291,666,299	321,922,130	297,698,617	283,570,560
Germany	258,223,763	281,979,467	305,714,664	270,594,952	259,139,786
Austria-Hungary	54,960,298	56,954,579	59,647,957	(*d*)53,396,400	(*d*)52,679,712
France	43,242,778	45,534,448	45,108,544	33,360,885	(*a*)20,000,000
Russia	29,361,764	33,775,754	37,188,480	36,414,560	31,158,400
Belgium	25,411,917	25,322,851	25,600,960	(*a*)19,000,000	15,691,465
Japan	19,436,536	21,648,902	23,988,292	21,700,572	...
India	13,494,573	16,471,100	18,163,856	18,439,974	...
China	16,534,500	16,534,500	(*a*)15,432,200	...	...
Canada	11,323,388	14,512,829	15,012,178	13,594,984	13,209,371
New South Wales	9,374,596	10,897,134	11,663,865	11,663,865	...
Transvaal (*b*)	7,112,254	7,591,619	8,191,243	7,778,706	7,557,771
Spain	4,316,245	4,559,453	4,731,647	4,897,360	5,358,670
New Zealand	2,315,390	2,438,929	2,115,834	2,548,664	...
Holland	1,628,097	1,901,902	2,064,608	1,763,696	(*a*)1,884,000
Chile	1,277,191	1,470,917	1,362,334	...	...
Queensland	998,556	1,010,426	1,162,497	1,180,825	1,147,186
Mexico	(*a*)1,400,000	982,396	...	...	...
Bosnia and Herzegovina	848,510	940,174	927,244	...	...
Turkey	799,168	909,293	...	...	...
Italy	614,132	731,720	772,802	861,265	...
Victoria	732,328	664,334	668,524	691,640	...
Orange Free State(*e*)	482,690	525,459	609,973	699,217	727,537
Dutch East Indies	(*a*)600,000	622,669	453,136	440,905	...
Indo-China	(*a*)460,000	471,259	...	...	...
Servia	335,495	335,000	...	...	...
Sweden	343,707	397,149	401,199	410,636	...
Western Australia	(*a*)300,000	330,488	351,687	357,515	...
Peru	(*a*)300,000	307,461	301,970	...	...
Formosa	280,999	306,941	...	...	...
Bulgaria	270,410	324,511	...	...	...
Rhodesia	212,529	216,140	237,728	391,394	458,934
Roumania	266,784	...	...	...	...
Korea	138,508	...	...	...	...
Tasmania	(*a*)70,000	59,987	61,648	68,130	66,000
British Borneo	(*a*)100,000	...	49,762	128,505	...
Spitzbergen	44,092	...	...	...	...
Brazil	16,535	...	...	...	...
Portugal	(*a*)10,000	16,938	27,653	...	...
Venezuela	(*a*)10,000	(*a*)12,000	13,355	...	...
Switzerland	8,267	...	...	...	...
Philippine Islands	(*a*)2,000	2,998	...	...	...
Unspecified	(*a*)1,016,947	...	...	...	...
Total	1,309,574,000	(*c*)1,377,000,000	(*c*)1,478,000,000	(*c*)1,334,000,000	

(*a*) Estimated. (*b*) Transvaal includes Natal and Cape of Good Hope and figures given are of coal sold only. (*c*) Approximate. (*d*) Hungarian production estimated at 10,000,000 short tons. (*e*) Represents coal sold only; probably 10 to 12 per cent. less than production.

Note.—This table is based on a compilation of the U. S. Geological Survey, supplemented by some later statistics. Most of the figures given for the years 1914 and 1915 are obtained from other sources and represent the best information available at this writing.

Coal in Foreign Countries

Australia.—The gross coal output for New South Wales for 1914 amounted to 10,390,622 tons, as compared with 10,414,155 tons in 1913. By far the largest proportion of the production originates in what is known as the northern district, which produced 7,113,991 tons in 1914, the southern district producing 2,362,741 tons and the western 913,890 tons. About 44 per cent., or 4,522,589 tons, of the production is used for home consumption, while 32 per cent., or 3,286,223 tons, is exported to foreign ports, and the remaining 24 per cent. is exported to different Australian ports. The decline in production for the year was probably due to labor disputes in the Maitland district, which was idle from May during the balance of the year.

The production of Victoria for 1914 amounted to 617,536 tons, showing an increase of 23,624 tons over 1913. Most of the coal comes from the State mine at Wonthaggi, the output for the year amounting to 550,107 tons.

Queensland produced 1,053,990 tons in 1914, as compared with 1,037,994 in 1913. The increases occurred in the Ipswich, Darling Douris and Clermont districts. The Ipswich mines are the chief producers, and about one-third of the output was exported and used for bunkering purposes.

In Tasmania only about 60,000 tons of coal was produced last year, practically all of this originating from one or two mines on the east coast.

Austria-Hungary.—The Austrian coal production in 1915 amounted to 16,083,074 tons, which compares with 15,411,369 tons for the preceding year. While the output apparently shows a gain of over half a million tons, it is still about 1,700,000 tons less than for a normal year. The lignite production showed a sharp decline from 23,772,069 tons in 1914 to 22,023,811 tons in 1915, while the coke output fell off from 2,189,913 tons in 1914 to 1,907,648 tons for 1915.

The production figures for Hungary are unfortunately much delayed, the latest statements available being those for 1913, in which year the coal output amounted to 1,320,000 tons and the lignite to 8,954,000 tons. These figures show a moderate increase over those for the preceding year, which were: Coal, 1,302,405, and lignite, 8,284,871 tons. The Hungarian coal industry has shown a fairly persistent expansion over the past few years, particularly in the output of lignite, which increased approximately one and one-half million tons during the period of 1909 to 1913.

Belgium.—According to figures originating from German sources the gross coal production of Belgium for 1915 amounted to 15,925,288 tons. No figures are apparently available for 1914, during the last half of which industrial operations were brought to a standstill through the war operations, but in the preceding year, 1913, the output was 22,858,000 tons. Production during the closing period of 1914 is estimated to have been about one-half normal.

Reviewing the year 1915 by quarters the output shows a persistent increase which would tend to indicate a gradual return to normal conditions. During the first quarter the output of coal was 2,950,237 tons, the second quarter, 3,175,687 tons, the third quarter 4,011,720 tons and in the last 4,110,528 tons. The Charleroi district is the leading producer, outputting 5,970,263 tons of coal, 129,974 tons of coke and 773,174 tons of briquettes.

China (By T. T. Read).—Coal production in China, which is roughly estimated at some 15,000,000 tons annually is increasing as most of the larger companies have increased their output. At the Fushun mine, in Manchuria, which is worked by a Japanese company affiliated with the South Manchurian railway, $1,000,000 to $1,500,000 is to be spent increasing the output, which is normally some 2,200,000 tons per year, 20,000 men being employed by the company. This company owns a gas producer plant in Korea and sells electric power to gold mining companies. From this it produces 10 tons of sulphate of ammonia per year; this is to be increased to 30 tons. A sulphuric acid plant is being built at Fushun to furnish the acid used in this industry, and the manufacture of dye-stuffs is under consideration. No reports have been given out as to the other Japanese operated mines in southern Manchuria, but development work has been active and a number of new properties are under consideration. Coal is mined in practically every province of China, about a dozen companies having modern equipment and the rest using native methods. The Japanese have taken over the mines formerly operated by the Germans in Shantung. I have not seen any recent statistics covering the output of the larger companies through out China.

France.—No authoritative figures concerning the performance of the French coal industry have appeared since the outbreak of the war, but it is estimated that production is being maintained at the rate of approximately 20,000,000 tons per annum, which is about one-half the normal output. In addition to this loss of 20,000,000 tons, France ordinarily imports this much more, so that the total apparent deficiency amounts to approximately 40,000,000 tons. It has developed, however, that consumptive requirements have been appreciably restricted by the slowing down in industrial activity incident to the war operations, this curtailment approximately equaling the loss in production of the French collieries. It thus appears that it is only necessary for France to maintain her normal imports to be assured of an adequate supply.

This, however, has proved a serious problem, since about one-third of the importations normally originate in Belgium and Germany, both of which sources of supply are naturally eliminated now. The remainder, about 11,000,000 tons per annum, is usually obtained from Great Britain, and in addition to this she has succeeded in making up the deficiency from

Belgium and Germany in a most impressive manner, the French imports from Great Britain for the year amounting to 17,500,000 tons, as compared with 12,330,000 tons during the preceding year.

The French production for 1914 amounted to 29,786,505 tons, which compares with 40,843,618 tons for the preceding year. The loss was confined chiefly to the second half, during which time war operations were initiated, the tonnage for that period amounting to only 9,347,713 tons, as compared with 20,438,792 tons for the first half.

Germany.—The German coal production in 1915 amounted to 146,-712,000 tons, as compared with 161,535,000 in 1914 and 191,511,000 in 1913, the last normal year preceding the war. In addition to the coal production there were 88,369,000 tons of lignite produced in 1915 and 26,359,000 tons of coke, besides a trifle less than 30,000,000 tons of briquettes.

Conditions in the coal industry are regarded as very satisfactory, in spite of the fact that fully one-third of the miners have been called into service in the army. The gross production naturally shows a heavy decline, but it is interesting to note that the output of lignite coal is the highest on record, exceeding that for the preceding year by nearly 5,000,000 tons and the previous high record of 1913 by more than 1,000,000 tons.

The scarcity of labor is being made up as far as possible by replacing the outside men with women and boys, so that the former can work on the inside, while a great many prisoners of war are also being employed underground. The increased cost of living has resulted in wage advances, high-class workers in the vicinity of Essen now receiving about $1.75 per day of 8 hr., as compared with $1.50 at the beginning of the war.

The coal handled by the syndicate during 1915 amounted to 73,-984,097 tons, which compares with 84,809,916 tons in 1914.

Great Britain.—The year 1915 witnessed a constantly increasing demand for coal, with an equally persistent decrease in the available supply. The chief difficulties were the inadequate supply of railroad cars, supplemented by an acute congestion, the heavy enlistment from the coal-mining region and the scarcity of mine timbers. Consumption, on the other hand, was at a maximum rate, due to an abnormal expansion in industrial operations throughout the country, and the year-end found the collieries all sold ahead for some time, while there was still a considerable demand to be met.

Prices advanced with such alarming rapidity over the first half of the year that the government was forced to establish a maximum level at about $1 above the maximum advance in 1914, though many large contracts had already been concluded at $1.45 to $1.70 above these figures.

The year was marked by many difficulties in the labor problem. Because of a sharp increase in the cost of living the Miners' Federation of Great Britain demanded a general advance of 20 per cent. in wages, and in May a compromise was effected by the English conciliation board on an increase of 15½ per cent., which was supplemented by a further increase of 5 per cent. at a later date. In spite of these awards, labor conditions continued much disturbed throughout the year, the situation reaching acute stages at times, as for instance the strike of the Welsh miners at a time when supplies were urgently required by the fleet.

A study of the British export trade for the year 1915 is of particular interest to American coal operators because of the numerous openings afforded them by the restricted trade of Great Britain in the world's coal markets. The history of the British foreign coal trade shows a practically uninterrupted increase from about 16,000,000 tons in 1873 to 98,000,000 tons in 1913, the gross shipments during this 40-year period amounting to nearly 2,000,000,000 tons, or about 40 per cent. of the total production of the country. The opening of the war in 1914 caused the first important break in this progressive increase, the loss in tonnage as compared with the preceding year amounting to over 27,000,000 tons. For 1915 this loss was increased to more than 38,000,000 tons, or more than one-third of the gross exports, if due allowance is made for the normal increase which might have been reasonably expected during this period.

Reductions in export are general to all countries with the exception of France, which took about 5,000,000 tons more in 1915 than in 1913. The heaviest declines of course are to enemy countries, Germany, Austria and Turkey, which together normally absorb from 10,000,000 to 12,000,000 tons of British coal and to which might also be added Russia, which has been practically cut off entirely from British shipping.

Holland.—This country depends almost entirely on Great Britain and Germany for its fuel supply and the restrictions in exports from both of these latter countries have created a serious condition in Holland. The imports for 1914 showed a decline of 2,453,000 tons, as compared with the previous year, the respective figures being 11,281,782 tons in 1914 and 13,734,843 tons in 1913.

Some test cargoes were shipped from the United States in 1915, which, it is estimated, were delivered at a price of $12 a ton, this comparing with about $8 a ton for the British and German products, these selling in normal times at approximately $4 per ton. Since, however, it has been more a question of getting supplies than of price, Germany having put in a regulation restricting exports by one-third, there is still a possibility of American coal finding a market.

Imports for 1915 indicate the development of a heavy shortage, the figures for the first 9 months being only 5,498,056 tons, as compared with 9,527,313 tons for the same period in 1914 and 10,184,354 tons in 1913. This loss, however, is overcome in a large measure by the practical cessation of exports, which amounted to only 240,412 tons during the first 9 months of 1915, as compared with 3,583,230 tons in the same period in 1914.

Italy.—American coal shipments to this country have increased at a rate never before witnessed in the history of our export trade, due entirely to the restricted movement from Great Britain which normally furnishes about nine-tenths of the country's requirements. The advent of the war curtailed British exports to Italy by nearly one-half, the coal tonnage for 1915 being only 5,788,460 tons, as compared with 9,647,161 tons for 1913, the last normal year. Imports from the United States for 1915 amounted to 2,931,581 tons, as compared with practically nothing for previous years.

The Italian production of coal is relatively insignificant. The output for 1914 was: Coal, 781,330 tons; coke, 1,276,318 tons; briquettes, 968,600 tons; which compare with the figures for 1913 as follows: Coal, 701,081 tons; coke, 1,336,382 tons; briquettes, 896,091 tons. There were 46 mines operating in 1914 and 40 in 1913.

New Zealand.—The production of New Zealand for 1914 showed a very substantial increase, amounting to 2,275,593 tons in 1914, as compared with 1,888,005 tons in 1913. The exports for 1914 amounted to 302,900 tons, as compared with 211,750 tons in 1913, and the imports for the same periods were, respectively, 518,000 tons and 469,000 tons. The output of the State colliery for 1914 amounted to 200,188 tons, exceeding that for the preceding year by 3906 tons. Of the gross production for New Zealand in 1914, 1,422,315 is designated as bituminous and semibituminous and the balance pitch coal, brown coal and lignite.

Norway.—The Norwegian coal and coke imports in 1914 amounted to 2,749,000 tons, as compared with 2,482,000 tons in 1913. For the first half of 1915 the imports show a gain as compared with 1914, the respective figures being 1,641,000 tons in 1915 and 1,366,000 tons in 1914. By far the largest proportion of the imports originate in Great Britain, though it is noted that Spitzbergen coal is growing rapidly in favor. Practically no American coal is exported to this country.

Peru.—(By Benjamin L. Miller and Joseph T. Singewald, Jr.) Next to Chile, Peru contains the largest known deposits of workable coal of any of the South American countries. In fact coal is more generally distributed throughout Peru than in Chile but, unfortunately, for the greater part in inaccessible regions not yet reached by railroads.

Bituminous coal is reported from the departments of Junin, Cajamarca, Ancachs, Ica, Puno, and Moquequa, extending through the entire range of the Peruvian Andes; anthracite coal occurs in the departments of Piura, Cajamarca, Lambaveque, Libertad, and Ancachs; while extensive deposits of lignite are said to occur near Tumbez and also near Janja. Nevertheless, Peru does not produce enough coal to supply the demand and, at present, the bulk of coal consumed within the country is imported.

About 90 per cent. of the Peruvian coal production is credited to the Cerro de Pasco Mining Company that operates two coal mines in the Department of Junin at Goyllarisquisga and Quishuarcancha. The entire output is consumed by the company, which without such a supply of coal, could scarcely operate with profit. The two mines are reached by branches of the Cerro de Pasco Railway Co., the Goyllarisquisga branch 26 miles in length and the Quishuarcancha line 10 miles. The construction of these branch lines was very expensive and yet they are not adapted for heavy traffic as the grades are very steep, with a maximum of 5 per cent.

The coal is of poor quality. As mined it is approximately one-third fixed carbon, one-third volatile matter, and one-third ash. When washed the coal produces a fair quality of coke and the smelter now uses this coke exclusively thereby effecting a considerable saving as the transportation charges on foreign coke were excessive. The coal is burned in bee-hive ovens located near the smelter.

At Goyllarisquisga four beds have been worked averaging 3, 4, 6, and 10 feet in thickness. The third bed is the most persistent, the others disappearing in depth, and even this one varies greatly in thickness with a maximum of 12 feet. At Quishuarcancha there is only one workable bed with an average thickness of about 7 feet.

In both mines there has been considerable folding and faulting which renders the mining operations more difficult. Much timber is required and, as the region is destitute of forests, all this must be brought from a distance. Some eucalyptus obtained near Huancayo is used, but the greater portion is Oregon pine. The timber is said to cost about 50 cents (U. S. currency) for every ton of coal mined.

During 1915 about 480 men were employed at Goyllarisquisga with a daily production of about 600 tons while at Quishuareancha 80 men were employed and the output was approximately 100 tons a day. Both mines are capable of increased production but unless the transportation facilities are improved there is little likelihood of the production being materially increased or that any eoal will be sold to other countries.

In several other places in Peru small amounts of coal are produced but the total amount is not large. The vanadium mines at Minasragra utilize for roasting the sulphide ore, a semi-anthracite which is brought in 100-pound bags on the backs of llamas. The output of such mines is necessarily limited.

Until other railroads are built to the various coal fields of Peru, the country will not materially increase its coal production.

Russia.—The production of coal in European Russia in 1915 amounted to 27,820,000 tons, as compared with 32,513,000 tons in 1914 and 33,-204,000 in 1913. The production in Asiatic Russia amounted to 2,798,-528 tons in 1915, as compared with 2,442,944 tons in 1914 and 2,153,648 tons in 1913. The Donetz Basin district continues far in the lead as the chief coal-producing district, outputting 26,084,856 tons in 1915, as compared with 27,065,248 tons the year before. The Dombrova district shows a heavy decline from 6,846,672 tons in 1913 to 3,712,632 tons in 1914 and nothing in 1915.

The loss of tonnage from the Dombrova district, together with the cessation of imports, restricted the amount of coal available for the market during 1915 by 15,268,000 tons, though this was partially compensated for by a reduction in the consumptive requirements of 8,036,000 tons owing to the German occupation of Poland and the Baltic Provinces and further by an increase in the amount of fuel oil available equal to several hundred thousand tons of coal. The coal imports in 1915 amounted to only 80,360 tons as compared with 5,416,000 tons in 1914 and 8,807,000 tons in 1913.

The coke production of European Russia for 1915 amounted to 4,001,000 tons, which compares with 4,467,000 in 1914. It is estimated that the production for 1916 will amount to 6,601,000 tons.

Spain.—The high prices and scarcity of coal in all export markets proved an incentive to domestic producers to increase their production during 1915, with a result that a new high record was established, the output of coal being 4,234,798 tons, as compared with 3,905,080 tons the preceding year and 3,783,214 tons in 1913. The anthracite output increased from 228,302 tons in 1914 to 252,483 tons in 1915, and the lignite production from 309,453 tons to 347,072 tons for the same years.

The heavy decline in imports has developed a very serious problem in Spain. The imports normally originate in Great Britain exclusively; the British exports to Spain and the Canaries in 1913 amounted to 3,648,-760 tons, 2,940,148 tons in 1914 and only 2,067,773 tons in 1915.

The chief producing district of Spain is Oviedo, from which the output was 2,700,000 tons of coal in 1915, as compared with 2,457,613 tons the year before.

Sweden.—Sweden has a very small coal production, the output for

1914 amounting to only 366,639 tons, as compared with 363,965 tons during the preceding year. The output originated entirely in 15 mines in the Scania district. The coal consumption in 1913 was estimated at 5,763,000 tons. Imports for the first 6 months of 1915 totaled 2,242,905 tons, as compared with 2,134,508 tons for the same period in 1914. In the last half of 1915 coal imports totaled 2,796,439 tons, making the total for the year 5,039,344, which compares with 5,064,371 tons in 1914 and 5,374,720 tons in 1913.

South Africa.—The total coal sold in the Union of South Africa for the year 1915 amounted to 8,281,311 tons, which compares with 8,477,923 tons in 1914 and 8,801,216 tons in 1913. Most of the production originates in the Province of Transvaal, the amount sold from there in 1914 being 5,157,268 tons, as compared with 5,225,036 tons in 1913.

The fuel imports into this country, while not important, have shown a very sharp decline, the total for the first half of 1915 amounting to only 9382 short tons, as compared with 28,201 tons for the same period in 1914. The importations of coke and patent fuel have been more nearly normal, the total for the first 6 months of 1915 being 11,754 tons, as compared with 10,956 tons in 1914. The exports form quite an important part of the fuel industry and showed a heavy decline for the first half of 1915, the total being 755,134 tons, as compared with 1,057,007 tons in 1914.

COPPER

By F. F. Hintze, Jr.

The copper industry as a whole has enjoyed an unusually prosperous year during 1915, perhaps more as a result of the war than in spite of it. The increased demand for copper, due to the extensive manufacture of munitions both in America and abroad, has steadily pushed the price of copper up to a point where small properties and those rather unfavorably situated could afford to operate their mines. The larger companies with the added inducements have forced their production to the highest possible point to take advantage of the ready market and the unusual prices offered for copper. Production figures from all of the copper-producing countries of the world, as far as they have been reported or estimated, indicate that 1915 is the banner year for copper, the total being slightly higher than that of 1912 which held the previous record.

The United States figured to a greater extent than ever before in the world's production of copper, furnishing 60.9 per cent. of the output, as against 56.4 in 1914, and 55.3 in 1913. The total output of this country during 1915 was 646,212 metric tons as compared with the combined output of all other countries of 415,071 metric tons. The increase in the production of the United States in 1915 was 30 per cent., while that of the rest of the world as a whole was only 6.7 per cent. Canada has increased its copper output the last year by 35 per cent.; Chile 15 per cent.; and Peru 35 per cent. Except for Mexico, which shows a further diminution on account of unfavorable internal conditions due to its civil war, the American countries have all had a great year.

At the beginning of the year 1915 the curtailment policy adopted by most of the large copper-producing companies in the middle of 1914 was still adhered to and ruled very largely during the first 3 months of the year, keeping the output below normal. Many of the smaller companies had closed down completely, and in some cases advantage was taken of the slackness to repair mining and milling machinery while operations were suspended or greatly reduced. Thousands of workmen were without employment, or working on a reduced wage scale during this period of stagnation.

The year opened with copper selling at 12.70 cts., but there was soon an improvement in the price as a result of the growing demand for copper, and this favorable situation continued during the first half of the year until in June the price had reached the extraordinary level of 20 cts. Encouraged by the steady growth in the demand and price the producers gradually increased their output until at the end of the first quarter they were producing at about normal rates, and by the middle of the year a noticeable effort was being made to swell the production. Workmen were in constant demand and wages were raised as the labor supply decreased. The outlook had thus steadily grown brighter and the copper industry had rallied to its former prosperous condition.

With the beginning of the second half of the year the price dropped several points and some apprehension was felt for the future.[1] Further reduction in the price was apparently to be expected as a result of the increased production unless the future demand, which was the most doubtful factor, should prove sufficient to prevent overstocking the market. Instead of declining, however, the price began to improve again and by the close of the year it was back to its former position around 20 cts. per lb. There was no lull in production corresponding to the slump in price and as the demand continued steady and strong the output remained close to the maximum during all of the last half of 1915.

The smelters' production of copper from American and imported ores and scrap during 1915 amounted to 1,676,313,769 lb., as compared with 1,398,484,346 lb. in 1914, and 1,516,796,972 lb. in 1913. Except for 40,062,900 lb. of export this huge output all went to American refineries along with 140,000,000 lb. of imported crude copper, making a total supply of 1,776,250,869 lb. available to American refiners. The following table shows the smelters' production for the last 5 years together with the deliveries to American and foreign refineries during that period:

SMELTERS' PRODUCTION
(In pounds)

Source	1911.	1912.	1913.	1914.	1915.
N. American ore	1,284,932,019	1,489,176,562	1,438,565,881	1,327,488,479	1,616,499,571
Foreign ore	34,392,091	53,701,307	55,803,202	50,101,308	44,538,207
Scrap	18,529,547	11,949,348	22,427,889	20,894,559	15,275,991
Totals	1,337,853,657	1,554,827,217	1,516,796,972	1,398,484,346	1,676,313,769
To foreign refiners	32,413,440	45,735,673	36,682,605	36,765,920	40,062,900
To American refiners	1,305,440,217	1,509,091,544	1,480,114,367	1,361,718,426	1,636,250,869
Crude copper imported	146,422,851	144,480,144	169,315,869	131,125,076	140,000,000
Total crude copper	1,451,863,068	1,653,471,688	1,649,430,236	1,492,843,502	1,776,250,869

The copper production of the several States for the last 6 years is given in the following table:[2]

[1] *Eng. Min. Jour.*, Aug. 21, 1915, p. 325.
[2] *Eng. Min. Jour.*, Jan. 8, 1916.

COPPER PRODUCTION OF THE UNITED STATES

(In pounds)

State.	1910.	1911.	1912.	1913.	1914.	1915.
Alaska	5,008,171	19,412,000	32,602,000	24,452,000	24,288,000	64,600,000
Arizona	299,606,971	300,578,816	357,952,962	399,849,745	387,978,852	443,094,331
California	45,793,894	36,806,762	31,069,029	32,390,272	29,515,488	38,343,927
Colorado	10,127,012	8,474,848	7,502,000	7,670,090	10,104,579	6,920,000
Idaho	6,216,461	3,745,210	5,964,542	8,434,028	4,856,460	5,720,000
Michigan	221,400,864	216,412,867	231,628,486	159,437,262	157,089,795	241,951,921
Montana	286,242,403	271,963,769	309,247,735	285,336,153	243,139,737	265,779,643
Nevada	63,877,500	65,385,728	82,530,608	84,683,961	60,078,095	65,598,475
New Mexico	3,632,351	1,518,288	27,488,912	46,953,414	64,338,892	67,827,730
Utah	125,042,381	138,336,905	131,673,803	147,591,955	153,555,902	188,080,000
Wyoming	180,861	....	1,121,109	448,805	165,023	351,871
Southern States	18,195,450	19,656,971	18,592,655	24,333,014	19,213,965	20,900,143
Other States	925,664	1,564,207	4,396,667	4,155,135	4,257,088	†15,472,524
Total	1,086,249,983	1,083,856,371	1,241,770,508	1,225,735,834	1,158,581,876	1,424,649,565

† Included in other States is a good deal of copper that could not be distributed as to origin at this time.

With one exception, Colorado, all of the States show increases in copper production. Very notable increases are shown by Alaska, Arizona, and Michigan, while Montana and Utah also made substantial advances over the output of the previous year. Arizona continues to hold first place with a lead of over 175,000,000 lb. over the output of its nearest competitor, Montana. Michigan made a record production, after 2 years of reduced output, running more than 50 per cent. in advance of the 1913 and 1914 figures.

The total production of new refined copper in 1915 was 1,634,204,448 lb. of which 1,397,705,523 lb. was produced from domestic, and 246,498,-925 lb. from foreign sources.[1] There was also produced during the year from secondary sources 59,574,690 lb. of refined copper, of which 38,156,789 lb. was electrolytically refined, and the remainder was cast. The total combined output of refined copper from all sources during the year was 1,693,779,138 lb., as compared with 1,565,708,374 lb. in 1914. The production of refined copper according to class for the past few years is given in the following table:

PRODUCTION OF COPPER IN UNITED STATES ACCORDING TO CLASS

(In pounds)

Year.	Lake.	Electrolytic. (*d*)	Casting. (*d*)	Pig Copper. (*a*)	Total.
1908	222,267,444	850,660,325	44,967,250	35,000,000	1,152,895,019
1909(*e*)	226,602,134	1,101,518,458	67,471,446	43,159,018	1,438,751,056
1910(*f*)	221,400,864	1,151,624,597	(*g*)55,673,196	46,903,463	(*g*)1,475,602,120
1911	216,412,867	1,156,627,311	22,977,534	35,920,626	1,431,938,338
1912	231,628,486	1,288,333,298	24,777,266	37,181,237	1,581,920,287
1913(*b*)	155,715,286	1,037,360,178	44,966,222	36,004,986	1,652,290,541
1914(*b*)	158,009,748	1,019,276,001	25,730,377	39,334,043	1,565,708,374
1915 (*b*)	236,757,062	1,152,502,131	42,973,030	15,047,990	1,447,280,213

(*a*) Exported. (*b*) Advance statement, U. S. Geol. Surv. (*c*) Partly estimated. (*d*) Included copper from scrap and junk. (*e*) The statistics for 1909 are officially communicated to us by the Copper Producers' Association, except that to its report of 34,123,446 lb. of casting copper we have added 33,348,000 lb. reported to us by the junk smelters. The term "Lake" copper is here used to designate all copper sold in the trade as such, regardless of the process by which it is refined. (*f*) Copper Producers' Association, through *Eng. Min. Jour.*, May 6, 1911. (*g*) Includes 23,480,000 b. from scrap.

[1] Advance Statement, U. S. Geol. Surv., Apr., 1916.

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In addition to the secondary material treated by the regular refining companies, plants that treated secondary material exclusively produced a total of about 332,700,000 lb. of copper as copper and in brass and other alloys of copper, making a total production of 392,274,000 lb. from secondary sources. Of this total at least 150,000,000 lb. was produced by re-melting clean scrap produced in the process of manufacture of copper and brass articles.

If the outputof plants treating purely secondary material is added to the production of the regular refining companies, the contribution from plants in the United States to the world's supply of copper for 1915 is found to be 2,026,000,000 lb.

In addition to the output of metallic copper the regular refining companies produced bluestone with a copper-content of 10,621,000 lb.

Consumption.—The apparent consumption of new refined copper in the United States in 1915 was about 1,043,000,000 lb., as compared with 620,445,373 lb. in 1914. The stock in the hands of the refiners at the beginning of the year was 173,640,501 lb., and the amount refined during the year was 1,634,204,448 lb., making a total available supply of 1,807,844,949 lb. The exports of refined copper amounted to 681,953,301 lb.,[2] and the stock on hand at the end of the year was 82,429,666 lb., which make when combined a total of 764,382,967 lb. of copper withdrawn from the supply, leaving an apparent consumption of 1,043,461,982 lb.

On account of the war it is impossible to state what the foreign consumption has been during the last year, but from the large demand for copper and the unusually high price paid for it there seems little room for doubt that the consumption has been high. The visible supply in European countries on Jan. 1, 1915 was 30,309 tons, and on Jan. 1, 1916 it was 20,064 tons, which corresponds to a decrease of 10,365 tons. Production figures are too incomplete to make a definite figure for foreign consumption possible, but the estimated foreign output shows a small increase over the preceding year, and this coupled with a decrease in the visible supply during the year indicates an increase in foreign consumption.

In the following table the consumption of copper in the United States during the last 10 years is given along with the production, the stocks at the beginning and close of the year, imports and exports, and supply:

The sum of production, stock Jan. 1, and imports gives the supply, and the difference between the supply and the sum of the exports and stocks at the end of the year gives the figure for the consumption.

[1] Advance Statement U. S. Geol. Surv.
[2] Bureau of Foreign and Domestic Commerce.

CONSUMPTION OF COPPER IN THE UNITED STATES

Year.	Production.	Stock Jan. 1.	Imports.	Supply.	Exports.	Stock Dec. 31.	Consumption.
1906(*a*)	917,620,000	132,587,496	225,593,281	1,275,800,777	467,839,041	139,385,400	668,576,336
1907...	1,152,747,890	9,000,000	5,000,000	1,166,747,890	508,929,401	120,000,000	537,818,489
1908...	1,152,895,019	120,000,000	....	1,272,895,019	661,876,127	122,357,266	488,661,626
1909...	1,405,403,056	122,357,266	....	1,527,760,322	682,846,726	141,766,111	703,147,485
1910...	1,452,122,120	141,766,111	....	1,593,888,231	708,316,543	122,030,195	763,541,493
1911...	1,431,938,338	122,030,195	....	1,553,968,533	786,553,208	89,454,695	677,960,630
1912...	1,581,920,287	89,454,695	....	1,671,374,982	775,000,658	105,312,582	791,061,742
1913...	1,622,456,829	105,312,582	....	1,727,769,411	926,441,142	91,348,867	709,979,402
1914(*b*)	1,533,781,394	90,385,402	....	1,634,166,796	840,080,922	173,640,501	620,445,373
1915(*b*)	1,634,204,448	173,640,501	....	1,807,844,949	681,953,301	82,429,666	1,043,461,982

(*a*) The statistics for 1906 are computed in the old way, namely, on the basis of the production of blister copper and the imports of copper in all forms. The stock on hand at the beginning and end of the year includes not only refined copper, but also the crude copper in transit and in process of refining. The statistics since 1906 are computed on the new and more accurate method described in *Eng. Min. Jour.*, July 25, 1908. Briefly, in this method the basis is production of refined copper, stock of copper in final marketable form and imports of refined copper. This change in method explains the erratic appearance of the figures for 1907 as compared with those of 1906. (*b*) U. S. Geol. Surv. estimate.

Exports.—The exports of copper in the form of ore, matte, and regulus during 1915 amounted to 11,831 long tons, and in the form of ingots, bars, plates, and scrap the amount was 681,951,311 lb. The accompanying table gives the exports to the different countries during the last few years.

EXPORTS OF COPPER FROM THE UNITED STATES (*a*)

Ore, matte and regulus stated in tons of 2240 lb. Ingots, etc., in pounds

Country.	1910.	1911.	1912.	1913.	1914.	1915.
Ore, matte and regulus	43,784	57,915	66,171	65,684	43,529	11,831
Ingots and scrap (*b*)						
Exported to:						
United Kingdom....	98,030,213	108,061,603	95,422,292	33,679,641	198,382,459	201,182,665
Belgium...........	7,176,258	5,125,C04	7,674,273	7,102,120	5,429,717	....
France............	116,193,850	135,038,893	131,362,694	160,000,345	150,839,897	236,236,135
Germany..........	175,861,028	190,428,008	252,156,012	307,150,761	176,698,948	....
Italy..............	34,110,237	38,216,773	47,251,432	41,568,713	67,415,944	107,101,230
Netherlands........	221,764,806	230,693,649	152,618,177	178,940,289	126,001,150	4,018,841
Russia.............	6,848,311	15,601,688	4,961,473	7,907,672	8,731,272	37,432,702
Austria Hungary...	....	44,200,202	38,558,151	34,648,205	26,989,548	....
Other Europe......	42,203,861	9,254,363	8,960,973	14,357,014	45,634,229	56,013,517
Brit. North America	5,628,487	8,931,582	30,302,856	36,182,257	24,221,498	24,127,182
Other countries.....	499,492	1,001,443	5,732,325	4,904,125	9,736,260	15,843,039
Total............	708,316,543	786,553,208	775,000,658	826,441,142	840,080,922	681,951,311

(*a*) The exports of ore, matte and regulus are reported as gross weight, the copper contents not being stated. (*b*) Includes bars and plates.

The figures show that the copper exports to Great Britain, France, Russia and Italy during 1915 far exceed the amounts that were sent to these countries in former years, with the exception of Great Britain whose imports of copper from this country in 1914 were almost as great as those of last year. The large increases in these instances is clearly due to the great demand for copper in the manufacture of munitions for use in the European war. It is also worthy of note that the Netherlands imported an almost insignificant amount of copper in 1915 as compared with its normal imports of the previous years. This condition is apparently due to the interference of Great Britain, whose purpose has been to prevent copper from reaching Germany through the neutral neighbors of that country; and it shows how effective the blockade has been in keeping copper from the central powers.

Imports.—The report of the Bureau of Foreign and Domestic Commerce shows that imports of copper in the form of ore and matte during 1915 amounted to 114,331,441 lb. net, as compared with 104,801,324 lb. in 1914; and in the form of pigs, bars, ingots, plates, and scrap, the 1915 imports amounted to 201,367,008 lb. as compared with 201,549,503 lb. in 1914. The total for 1915 is seen to be about 10,000,000 lb. greater than in the previous year, and most of this increase was due to copper in the form of ore and matte. The figures from the different countries show Cuba increased its shipments to the United States by about the amount of the yearly increase, while Canada shows a small increase, enough to account for the decrease due to the lack of imports from Germany. The imports from the various countries during the last few years is shown in the accompanying table:

IMPORTS OF COPPER INTO THE UNITED STATES (*a*)
(In pounds)

Country.	1910.	1911.	1912.	1913.	1914.	1915
Ore and matte						
Imported from:						
Germany	....	....	....	1,067,024	4,684,448	....
Spain	....	....	....	6,244,676	2,633,395	1,278,403
Cuba	....	....	....	5,362,132	18,659,788	28,876,226
Brit. North America	10,024,806	12,919,644	28,930,073	34,072,096	24,584,124	29,591,823
Mexico	22,731,184	16,684,071	18,069,987	19,722,530	15,495,694	14,707,724
South America	19,425,233	15,305,335	26,749,545	(*c*) 25,311,542	(*c*) 30,562,839	34,435,039
Other countries	33,033,752	23,717,628	31,122,098	17,712,105	8,180,816	6,442,226
Total	85,224,975	68,626,678	104,871,703	109,492,105	104,801,324	114,331,441
Pig and Scrap (*b*)						
Imported from:						
United Kingdom	18,649,727	9,004,461	1,404,118	17,943,285	5,163,126	7,485,625
Other Europe	25,411,383	28,042,257	31,670,095	(*d*) 36,565,767	(*d*) 16,931,784	7,964,534
Brit. North America	29,016,785	22,442,335	36,138,255	33,749,133	27,230,559	44,977,829
Mexico	84,008,907	97,115,574	124,742,193	97,003,847	43,193,868	15,973,838
Chile	....	5,175,823	8,627,421	18,315,000	23,814,659	36,303,505
Peru	....	42,545,031	43,891,439	42,667,436	44,488,809	61,342,067
Australia and Tasmania	....	22,426,670	24,700,333	22,149,335	15,130,001	443,520
Japan	18,482,989	20,030,447	19,511,402	14,367,493	10,918,069	17,970,768
Other countries	83,640,995	19,197,254	14,684,336	17,298,533	14,678,628	8,905,322
Total	259,210,786	265,980,760	305,369,592	300,059,829	201,549,503	201,367,008

(*a*) The imports reported are the copper contents of ore, mate, and regulus. (*b*) Includee also bars, ingots, and plates. (*c*) All from Chile. (*d*) All from Spain.

World's Production

Statistics on the copper production of the different countries of the world as given in the following table are taken from various sources, the figures for 1915 being mostly those given out by the *Engineering and Mining Journal.* Only the production from domestic ores and raw products is included. On account of the war no official statistics have been obtainable for many of the foreign countries, but in some cases estimates that are thought to be fairly correct have been given. The returns

THE WORLD'S COPPER PRODUCTION
(In metric tons)

Country.	1906.	1907.	1908.	1909.	1910. (*h*)	1911.	1912.	1913.	1914.	1915.
Africa (*a*) Cape Co.	4,003	4,298	4,550	4,720	} 7,016	17,252	16,633 {	5,812	3,125	} *27,000
Africa (*a*) Namaqua	2,642	2,540	2,440	2,337				2,540	2,328	
Africa (*a*) Other	....	....	....	8,128	8,433	....	....	17,059	18,682	
Argentina (*a*)	107	224	226	610	305	1,036	335	117	....	....
Australasia (*a*)	36,830	41,910	40,123	34,952	40,962	42,512	47,774	47,326	37,59	32,512
Austria-Hungary (*a*)	1,458	1,062	3,877	6,218	2,276	2,566	4,024	4,135	3,310	....
Bolivia (*a*)	2,540	21,035	2,540	2,032	2,540	(*d*) 2,950	(*d*) 4,681	3,658	2,743	* 3,000
Canada (*d*)	19,110	2,540	24,376	21,626	23,810	25,570	34,213	34,587	34,027	47,202
Chile (*d*)	25,829	28,863	42,097	42,726	38,346	33,088	39,204	40,195	40,876	47,142
Cuba (*d*)	1,384	1,388	2,966	3,006	3,538	3,753	4,393	3,517	6,251	8,836
Germany—total (*a*)	20,665	20,818	20,523	32,815	25,105	22,363	24,304	25,309	30,480	35,000
(Mansfeld) (*a*)	(18,085)	(17,343)	(18,000)	(19,015)	(20,275)	....	....	(20,201)	....	....
Italy (*a*)	2,911	3,353	3,022	2,769	3,272	2,642	2,337	1,626	2,410	....
Japan (*f*)	36,963	40,183	41,399	42,987	50,703	*d*) 52,303	*d*)62,486	*a*)73,152	68,058	*75,000
Mexico—total (*d*)	61,615	57,491	38,190	57,230	62,504	61,884	73,617	52,815	36,337	30,969
(Boleo) (*a*)	(11,002)	(11,506)	(12,600)	(12,426)	(13,003)	....	....	(13,020)	....	....
Newfoundland (*a*)	2,332	1,758	1,453	1,402	1,097	1,174	549	....	....	....
Norway (*a*)	6,218	7,122	9,337	9,226	10,592	9,576	11,156	11,796	*11,000	(*d*)32,410
Peru (*e*)	13,474	20,681	15,240	16,257	27,375	28,500	*f*)26,483	*d*)25,715	23,647	*16,000
Russia (*c*)	9,296	15,930	17,718	18,035	22,670	25,747	33,550	42,970	31,938	*35,000
Spain-Portugal (*a*)	50,109	50,470	53,425	53,023	51,080	51,748	59,876	54,696	37,099	....
Rio Tinto (*a*)	34,642	32,833	35,517	35,938	(34,114)	(35,100)	....	36,901	21,515	....
Tharsis (*a*)	4,816	4,206	4,500	4,425	(3,551)	(3,450)	....	3,270	....	....
Mason & Barry (*a*)	2,504	2,662	2,804	2,403	(3,003)	(2,972)	....	3,185	....	....
Sevilla (*a*)	2,073	2,337	2,196	1,849	(1,656)	(1,558)	....	1,535	....	....
Sweden (*c*)	1,209	1,577	2,808	2,032	2,032	2,032	(*a*)1,524	(*a*)1,016	....	....
Turkey (*a*)	432	1,270	1,068	813	610	1,016	508	508	....	....
United Kingdom (*g*)	762	677	588	442	508	405	405	305	....	....
United States (*d*)	416,343	398,930	430,399	501,372	492,720	491,634	563,260	557,387	525,529	646,212
Total	715,510	724,120	758,065	854,758	877,494	879,751	1,011,312	1,002,284	934,888	1,061,283

(*a*) As reported by Henry R. Merton & Co., Ltd., of London. (*c*) As officially reported, except for 1909, for which year the figure of Henry R. Merton & Co. is used. (*d*) As reported by the *Eng. Min. Jour.* (*e*) As officially reported 1903–1907, as per Henry R. Merton & Co. for 1908 and 1909. (*f*) As officially reported, (*g*) As officially reported, 1900–1905; subsequently as per Henry R. Merton & Co. (*h*) Henry R. Merton & Co., through *Eng. Min. Jour.* * Estimated.

WORLD'S PRODUCTION OF COPPER (*a*)

Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.	Year.	Metric Tons.	Short Tons.
1882	184,620	203,550	1893	310,704	342,562	1904	693,240	764,758
1883	202,697	223,481	1894	330,075	363,920	1905	698,931	770,221
1884	223,884	246,840	1895	339,994	374,856	1906	715,510	788,492
1885	229,315	252,828	1896	384,493	423,917	1907	724,120	798,205
1886	220,669	243,295	1897	412,818	455,147	1908	758,065	835,623
1887	226,492	249,716	1898	441,282	486,529	1909	854,758	942,408
1888	262,285	281,179	1899	476,194	525,021	1910	877,494	966,998
1889	265,516	292,741	1900	491,435	541,561	1911	879,751	969,750
1890	274,065	302,166	1901	529,508	583,517	1912	1,011,312	1,114,769
1891	280,138	308,862	1902	542,606	597,951	1913	1,002,284	1,104,517
1892	309,113	340,808	1903	630,590	694,910	1914	934,888	1,018,395

(*a*) The statistics for 1881–1891 are as reported by Henry R. Merton & Co.; 1892–1910 as per MINERAL INDUSTRY.

from the United States, Mexico, Canada, Cuba, Peru, Chile, Australia, and Japan are approximately complete. Mexico shows a further decrease as a result of the continuation of hostilities within the republic, Chile has increased notably, and is expected to show a further increase in 1916, and Japan has forced her copper production partly for domestic consumption, but largely for exportation during the present period of unusual demands and prices.

Price.—The average price of electrolytic copper in New York during the first month of 1915 was 13.641 cts. per lb., which is less than it was during the corresponding months of the preceding 3 years. The year opened with copper at 12.70 cts. and there was a steady increase in the price during the first 6 months, at the end of which copper was selling around 20 cts. The large sales of copper made in June seemed to satisfy the demands for the next few months and there was a decline in the price to about 17.5 cts. per lb. In November there was a strike at the Nichols refinery which started buying movements among the consumers who feared a shortage and the price advanced sharply to around 19.5 cts. by the middle of the month. In spite of the high price a large volume of business was consummated during November, falling but little below that of June. In December the market became more stable but the price remained around 19.5 cts. until the middle of the month when the consumers were forced to buy on account of shortages and the demand became strong. On Dec. 22 a sale of 60,000 long tons of copper to the British government at 20 cts. per lb. was announced and when this news was spread about and it became known that but little unsold copper would be available until the end of the first quarter in 1916 buyers became excited and the price went up to 22.5 cts. by the end of the month.

The average monthly prices of electrolytic in New York and of standard copper in London, together with the average monthly prices of copper manufactures are given in the accompanying tables:

AVERAGE PRICE OF ELECTROLYTIC COPPER PER POUND IN NEW YORK (*a*)
(In cents per pound)

Year	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1904.	12.410	12.063	12.299	12.923	12.758	12.269	12.380	12.343	12.495	12.993	14.284	14.661	12.823
1905.	15.008	15.008	15.125	14.920	14.627	14.673	14.888	15.664	15.965	16.279	16.599	18.328	15.590
1906.	18.310	17.869	18.361	18.375	18.457	18.442	18.190	18.380	19.033	21.203	21.833	22.885	19.278
1907.	24.404	24.869	25.065	24.224	24.048	22.665	21.130	18.356	15.565	13.169	13.391	13.163	20.004
1908.	13.726	12.905	12.704	12.743	12.598	12.675	12.702	13.462	13.388	13.354	14.130	14.111	13.208
1909.	13.893	12.949	12.387	12.563	12.893	13.214	12.880	13.007	12.870	12.700	13.125	13.298	12.982
1910.	13.620	13.332	13.255	12.733	12.550	12.404	12.215	12.490	12.379	12.553	12.742	12.581	12.738
1911.	12.295	12.256	12.139	12.019	11.989	12.385	12.463	13.405	12.201	12.189	12.616	13.552	12.376
1912.	14.094	14.084	14.698	15.741	16.031	17.234	17.190	17.498	17.508	17.314	17.326	17.376	16.341
1913.	16.488	14.971	14.713	15.291	15.436	14.672	14.192	15.400	16.328	16.337	15.182	14.224	15.269
1914.	14.223	14.491	14.131	14.211	13.996	13.603	13.223	(*b*)	(*b*)	(*b*)	11.739	12.801	......
1915.	13.641	14.394	14.787	16.818	18.506	19.477	18.796	16.941	17.502	17.686	18.627	20.133	17.275

(*a*) From *Eng. Min. Jour.* (*b*) No quotation.

AVERAGE PRICE OF STANDARD COPPER (G. M. B.'s) IN LONDON (*a*)
(In pounds sterling per ton of 2240 lb.)

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1904.....	57.500	56.500	57.321	58.247	57.321	56.398	57.256	59.952	57.645	60.012	65.085	66.375	58.884
1905.....	68.262	67.963	68.174	67.017	64.875	65.881	66.887	69.830	69.667	71.406	74.727	78.993	69.465
1906.....	78.869	78.147	81.111	84.793	84.867	83.994	81.167	83.864	87.831	97.269	100.270	105.226	87.282
1907.....	106.739	107.356	106.594	98.625	102.375	97.272	95.016	79.679	68.375	60.717	61.226	60.113	87.007
1908.....	62.386	58.786	58.761	58.331	57.387	57.842	57.989	60.500	60.338	60.139	63.417	62.943	59.902
1909.....	61.198	57.688	56.231	57.363	59.338	59.627	58.556	59.393	59.021	57.551	58.917	59.906	58.732
1910.....	60.923	59.388	59.214	57.238	56.313	55.310	54.194	55.733	55.207	56.722	57.634	56.069	57.054
1911.....	55.604	54.970	54.704	54.035	54.313	56.368	56.670	56.264	55.253	55.176	57.253	62.063	55.973
1912.....	62.760	62.893	65.884	70.294	72.352	78.259	76.636	78.670	78.762	76.389	76.890	75.516	72.942
1913.....	71.741	65.519	65.329	68.111	68.807	67.140	64.166	69.200	73.125	73.383	68.275	65.223	68.355
1914.....	64.304	65.259	64.276	64.747	63.182	61.336	60.540	(*b*)	(*b*)	(*b*)	53.227	56.841	....
1915.....	60.756	63.494	66.152	75.096	77.600	82.574	76.011	68.673	68.915	72.601	77.744	80.773	72.532

(*a*) From *Eng. Min. Jour.* (*b*) No quotation.

AVERAGE MONTHLY PRICES OF COPPER MANUFACTURES (*a*)
(In cents per pound)

	1913.		1914.		1915.	
	Wire.	Sheet.	Wire.	Sheet.	Wire.	Sheet.
Jan..................	19.09	23.50	15.94	20.75	14.80	19.50
Feb..................	16.38	22.50	15.88	20.50	15.19	20.25
Mar..................	16.39	21.50	15.60	20.35	16.09	20.63
Apr..................	16.50	21.50	15.25	20.25	18.03	22.38
May..................	16.50	21.50	15.23	19.90	19.95	24.50
June..................	16.18	21.10	15.03	19.56	21.13	25.25
July..................	15.88	20.50	14.88	19.38	21.63	25.50
Aug..................	16.60	21.50	14.63	18.80	19.25	23.90
Sept..................	17.84	22.50	14.34	18.00	19.34	23.50
Oct..................	17.75	22.50	13.34	17.38	19.28	23.50
Nov..................	17.28	21.15	12.50	17.50	19.84	24.44
Dec..................	15.79	20.50	14.25	18.88	21.81	26.00
Year..............	16.85	21.69	14.74	19.24	19.21	22.93

(*a*) *Eng. Min. Jour.*

Copper Mining in the United States

Alaska.—The total production of copper in Alaska to the close of 1915 was 219,913,375 lb., valued at $34,919,581, and of this amount 86,509,312 lb. valued at $15,139,129 was produced in 1915. This is more than four times the output of 1914, and by far the greatest in the history of the Alaska copper industry.[1] Thirteen mines were worked for copper in 1915 as compared with seven in 1913. A total of 369,600 tons of ore was mined last year which carried in addition to the copper, values in gold and silver amounting to $608,325.[1]

The enormous increase in the copper production of Alaska is the result of thc high prices that have prevailed over a large part of the year, enabling the smaller companies to re-open their mines, and also due to the larger developments that have been under way for several years past. The great demand for copper is perhaps the chief factor in hasten-

[1] Alfred H. Brooks, *Press Bull.* 268, Apr. 17, 1916, U. S. Geol. Surv.

ing the large scale production of Alaska, which from present indications will continue for a long time. The 1915 output came from seven mines in the Ketchikan district, four on Prince William Sound, and three in the Chitina district.

The copper deposits of the Ketchikan district, southeastern Alaska, were known to the Russians before the acquisition of the Territory by the United States, and there was a crude attempt to develop them as early as 1880. It was not until 1901, however, that systematic mining was begun and not until 1905 that a large annual output was made. Up to the close of 1913 the copper mines of the Ketchikan district had produced about 22,640,000 lb. of copper, valued at $3,760,000, and $500,-000 worth of gold and silver.

Most of the mines of the district lie at or near tidewater. There is an abundance of timber, and the relief favors the undercutting of the ore bodies. While there are as yet only a few producing mines, there are many undeveloped copper prospects which give promise of containing commercial ore-bodies. Many of the copper deposits show an irregularity of occurrence that is unfavorable to cheap exploitation, but otherwise the conditions are favorable to low mining costs.

Copper River.—The enormous output of copper from the Bonanza and Jumbo mines, in the Chitina district, overshadowed all other operations. The adjacent Mother Lode mine was, however, also operated throughout the year. Its actual shipments are as yet limited to the winter season, as the ore is sledded to the railway, a distance of 14 miles. Ore shipments from this district were interrupted for several weeks during the summer on account of the burning of several railway bridges. Work was continued on a number of other copper properties, but they made no output and details regarding development are yet lacking.

During 1915 the copper mines near Kennecott owned by the Alaska Syndicate were transferred to the Kennecott Copper Corporation, and the stock of this company was placed on the market. These mines produced from the time of the formation of the Kennecott Copper Corporation, May 27, 1915, to Nov. 30, 1915, approximately 52,000,000 lb. of copper, averaging about 8,660,000 lb. per month, at a cost of under 5 cts. per lb. During November the production exceeded 10,000,000 lb.

The developments in the Jumbo mine were especially remarkable. On the 500-ft. level of this mine there is a stope that averages over 70 per cent. copper for a width of 70 ft. All the ore from this stope is shipped directly to the smelters and returns between 1350 and 1500 lb. of copper per ton. Some of the ore from other parts of the mine is first concentrated in a mill situated at a lower altitude, about 3 miles from the mine, with which it is connected by an aërial tramway. Construction of a leaching plant to treat the tailings from the concentrator was commenced during 1915. Additions and improvements to the concentrator have resulted in increasing its capacity to 800 tons per day.

The corporation's mines in Alaska produced during the 7 months of its operations ended Dec. 31, 1915, approximately 63,000,000 lb. of copper at a cost of less than 5 cts. per lb. Of this but 57,555,183 lb. was received at smeltery and taken into profit and loss. The balance was en route and is carried at actual cost of mining and milling. Total costs on poundage received at smeltery were as follows:

	Per Lb., Cents.
Mining and milling	1.19
Freight to smeltery	2.18
Smelting and refining	1.37
Selling	0.18
General expense	0.06
Marine insurance	0.09
Proceeds silver contents	*0.52
Miscellaneous earnings	*0.01
	4.54

*Deduction.

The average copper content of product shipped from both mines during the 7 months was 60.11 per cent.

Prince William Sound.—The operation of four or five copper mines and four gold mines constituted the principal mining activity of the year in this region. The value of the total product was about $1,400,000, against $1,198,742 in 1914. The Ellamar copper mine was operated on about the same scale as in the past. Operations were also resumed in 1915 at the Three Friends, and copper ore was shipped. The McIntosh mine, on Fidalgo bay, made some copper production, and it is reported that some ore was taken at the nearby Dickey mine, although no shipments were made. Large operations were continued at the Beatson copper mine, on Latouche island. The tram connecting the Midas copper mine with Port Valdez was completed in October, and since that time productive mining has been undertaken. In addition to the productive copper mines noted above, there were developments on many other properties.

Arizona.—During 1915 Arizona continued to lead all the states in the production of copper, holding the first place by an excess of more than 160,000,000 lb. over its nearest competitor Montana, and almost double that of Michigan, the third greatest copper state in the Union. The output of 1915 amounted to 432,467,690 lb. as compared with 382,449,922 lb. in 1914, and 404,278,809 lb. in 1913,[1] corresponding to increases of 39 and 7 per cent. respectively for the 2 years.

The policy of curtailment that had been pursued by the large producers during the last half of 1914 continued in force during the first quarter

[1] Advance Statement, U. S. Geol. Surv.

of 1915, keeping the output below its normal level. The steady demand for copper and the growing price gradually forced the producers to remove all restrictions on production, and induced them to swell the output beyond the previously established limits during the last 9 months of the year.

In July, 1915, the Inspiration Copper Co. entered the ranks of producers, actual underground mining having been started on July 25. The first unit of the mill went into operation on June 29, and during the following months of the year additional units of the mill were put into service as fast as they reached completion. By the end of December 12 units out of the 18 under construction were in use. During the 6 months 778,851 tons of ore was concentrated, all coming from underground work except 7858 tons of reclaimed material from the Joe Bush and Scorpion dumps. The copper production for the period amounted to a total of 20,445,670 lb., of which all but 378,360 lb. which was recovered from oxide ore sent direct to the smelter, was produced from the concentrates. The results of the milling operations and the costs of producing copper from the concentrates are given in the following tabulation:

	Copper, Per Cent.
Assay of ore milled	1.702
Oxide copper in ore	0.226
Assay of tailings	0.373
Oxide copper in tailings	0.180
Assay of concentrates from flotation	37.630
Assay of concentrates from tables	13.120
Average assay of concentrates—total made	32.670
Average recovery of total copper in ores milled	79.950
Average recovery on sulphide copper in ores milled	88.560

To produce 1 ton of concentrates 24.6 tons of ore was required. The cost of copper derived from concentrating ores was:

	Cost per Lb.	Cost per Ton Ore.
Mining	2.664c.	$0.68110
Coarse crushing	0.113	0.02910
Ore hauling	0.079	0.02025
Concentrating and royalty	1.889	0.48675
Concentrate hauling	0.006	0.00160
	4.731c.	$1.21880
Smelting, freight, refining, marketing, etc	3.455	0.76420
	8.136c	$1.9830
	20,067,310 lb.	778,851 tons

The operating costs at Inspiration for mining and milling will probably be from $1 to $1.15 per ton of ore, possibly nearer the former figure. While a yield of more than 20 lb. per ton of ore can be obtained from much of the ore, a better mining practice can be followed and more ultimate profits obtained by mining ore producing 20 lb. on the average. The cost of the 378,360 lb. of copper from crude ores sold was 7.65 cts., which, when combined with costs of the rest of the copper produced, makes an average cost for all of 8.132 cts. per lb.

Phelps Dodge & Co., controlling the Copper Queen Mining Co., Detroit Copper Mining Co. of Arizona, Moctezuma Copper Co., Burro Mountain Copper Co., Stag Canyon Fuel Co., and Phelps Dodge Mercantile Co., reports a total production from its subsidiaries during 1915 of 104,478,003 lb. of copper, which is an increase of 8,815,679 lb. over the output of the previous year. Including copper received from outside sources there was sold and delivered during the year a total of 194,925,-668 lb. of copper at an average price of 16.079 cts. per lb. Nearly one-half of this was sold to domestic trade, and slightly over one-half to foreign consumers. These excellent results were obtained despite the curtailment in effect during the first 2 months of 1915, the strike at the Detroit mines in Arizona during the last quarter of the year and the Mexican troubles, which repeatedly paralyzed the railroad transportation between the Moctezuma Copper Co.'s property in Sonora and the Douglas reduction works, the Nacozari plant being idle for 135 days.

The strike at the Detroit Copper Mining Co. in Morenci, while suspending production from September, 1915, to February, 1916, did not result in any great damage to the property and developed some novel features, the most striking of which was the housing of loyal workmen at company expense at a distance from the strike area.

The Copper Queen mines shipped 783,211 dry tons from Bisbee, besides precipitates and old-dump slag, bringing the total up to 830,777 tons, containing 88,551,180 lb. of copper, 943,368 oz. of silver, 18,974 oz. of gold and 9,388,418 lb. of lead. The ore reserves in the limestone division of the mines at Bisbee remained approximately the same as at the commencement of the year, 2,696,940 tons, and churn drilling extended the previously discovered bodies of disseminated ores, for which a large concentrator is to be erected. The average grade of the copper ore mined from the limestone was about 6 per cent. In the disseminated area of Sacramento Hill prospecting by churn drilling brought up the ore reserves to 8,542,836 tons averaging 2.732 per cent. copper, assuming a minimum of 1.3 per cent. copper-content. If the minimum is put down to 1 per cent. the tonnage rises to 11,633,480, averaging 2.445 per cent. copper. Notwithstanding the extension of the Sacramento Hill ore body, there remains much unexplored ground. Tests on a working scale in an experimental mill have demonstrated that 1.3 per cent. of copper will be profitable, and it is possible that 1 per cent. material can be worked. A recovery of 85.45 per cent. of the copper was made in a test of 4407 tons of ore averaging 2.96 per cent. Cu; the ratio of concentration was 3.24:1.

The dividends paid by the company during the year were $9,000,000, and the surplus at the end of the year stood at $8,337,863. It is noteworthy that among the assets of the company are listed 5-year Anglo-French External Loan bonds, amounting to $1,940,000. Cash on hand was nearly $6,000,000 at the end of the year.

At the Burro Mountain Copper Co., in New Mexico, construction work was actively carried forward and the concentrator was practically completed. The property of the Sevanna Copper Co. adjoining the Burro Mountain property was purchased and development has been undertaken.

Work by the Bunker Hill Mines Co., at Tombstone, Ariz., has not progressed far enough to determine the fate of this property. About 2000 tons of manganese ore was mined, and 8000 tons of silver-gold-copper-lead ore was taken out and shipped to the experimental cyanide plant for study and treatment.

Notwithstanding that the train service between Nacozari, Son., and Douglas, Ariz., was interrupted during the greater part of 1915, a net production of 22,889,885 lb. of copper is reported by the Moctezuma Copper Co., and some important improvements have been planned. During the year 424,027 tons of ore assaying 3.412 per cent. copper was milled, with a recovery of 83.6 per cent. of the copper in 90,014 tons of concentrates assaying 13.316 per cent. copper.

According to the report of the New Cornelia Copper Co., a subsidiary to the Calumet and Arizona Mining Co., operations at the property at Ajo, Ariz., were continued throughout the year, a 40-ton experimental plant having been kept going since Feb. 1. The results of the experimental work were such that a permanent plant costing $4,200,000 has been ordered. The new plant when completed will put the property on a production basis of 36,000,000 lb. of copper per year, and it is estimated that the work of constructing the plant will be completed by July 1, 1917.

The annual report of the Ray Consolidated Copper Co., Ray, Ariz., states that the year 1915 was the most prosperous period in the company's history. At the close of the year the output was sold farther ahead than ever before. Dividends at the rate of 37½ cts. per share quarterly were resumed in the second quarter of the year, and this rate was increased to 50 cts. in the fourth quarter. There were outstanding at the close of business on Dec. 31, 1915, 1,571,279 shares of capital stock. The year's operations resulted in an increase of net current assets of $2,084,856.88. Miscellaneous income was $376,691; total income $4,750,062.

During the year no development work was done for the direct purpose of proving additional ore reserves, but a total of 45,292 ft. of underground work was driven in the conduct of active mining operations in areas tributary to the three shafts. This is 29,969 ft. less than for the previous year. There will be some increase in development during the coming year, as the work of opening up the third level at shafts Nos. 1 and 2 will be prosecuted vigorously. On completion, this level, in conjunction with the two main levels already developed, will serve all the ore tributary to the two main shafts. When this work is finished, there will be no further expenditures for main haulageways, and development will then consist of the less expensive work directly incident to mining operations. The total development since the beginning of operations and up to the end of the year 1915 is 497,525 ft., or approximately 100 miles, of which mining operations have destroyed 224,698 ft., or about 45 miles. During the year 2,854,314 tons of ore was mined, leaving of the originally developed and reported ore-body, 71,911,475 tons averaging 2.235 per cent. copper. The 2,854,314 tons of ore mined consisted of 2,852,577 tons of concentrating ore averaging 1.673 per cent. copper and 1737 tons of sorted ore from the No. 3 shaft, which was shipped direct to the smeltery.

The total ore milled for the year was 2,848,969 tons, corresponding to a daily average of 7805 tons, as compared with 2,427,700 tons for 1914. The total tonnage of ore milled since the beginning of operations and to the end of 1915 was 9,889,360 tons, averaging 1.717 per cent. copper. The average grade of the ore milled for 1915 was 1.673 per cent. copper, as compared with 1.76 per cent. for 1914. The average recovery was 64.11 per cent., corresponding to 21.45 lb. of copper per ton as compared with 67.88 per cent. or 23.9 lb. per ton, for the previous year.

Operating statistics compare as follows:

	1915.	1914.
Rock hoisted, tons	948,914	590,094
Rock house discard	40	175
Per cent. of discard	0.004	0.03
Rock treated, tons	948,874	590,519
Cost of mining, transp., stamping and taxes	$1.26	$1.55
Mineral obtained, lb	32,292,325	20,333,000
Refined copper produced, lb	21,800,492	13,624,605
Per cent. of copper in mineral	67.50	67.06
Lb. refined copper per ton rock stamped	23.0	23.1

The costs per pound of copper shows:

Mining	5.48c.	6.73c.
Construction	0.81	1.68
Smelting, freight, etc	1.67	1.30
Totals	7.96c.	9.71c.

The Ray Hercules Copper Co. has been organized to acquire a large majority of the capital stock of the Arizona Hercules Copper Co., operating in the Ray district of Arizona. The ore-body is said to be a continuation of the Ray Consolidated.

The Old Dominion Copper Mining and Smelting Co., Globe, Ariz., for 1915 reports a profit of $1,337,086 from the production of 27,736,158 lb. of refined copper, 150,621 oz. of silver and 2937 oz. of gold, including custom ores. Of this production 13,771,681 lb. of copper, 40,632 oz. of silver and 620 oz. of gold came from Old Dominion ores and 13,964,477 lb. of copper, 109,988 oz. of silver and 2316 oz. of gold from custom ores. The average price received for copper was 18.61 cts. per lb. and for silver, 49.59 cts. per oz. Total receipts from the sale of metals were $2,595,431 and smelting profits on custom ores and miscellaneous income amounted to $259,415, making total receipts $2,854,846. Total expenses were $1,517,760. Dividends totaled $810,000 for the year. Depreciation amounting to $572,351 on plants and $195,023 on mines was charged off surplus account and not included in the expenses stated. A balance of $1,223,332 in quick assets was on hand at the close of the year. The following table gives a comparison of tonnages and grades of ore for 1914 and 1915:

	Dry Tons, 1915.	Extracted, 1914.	Average Grade, 1915.	Per Cent. Cu, 1914.
Smelting ore	80,512	99,507	7.81	8.28
Concentrating ore	32,380	30,159	3.72	4.69
Siliceous ore	2,567	147	3.65	3.12
Total	115,459	129,813	6.56	7.44

Mining costs in 1915 were $5.51 per ton, compared with $5.20 per ton in 1914. Development work consisted of sinking, 334 ft.; drifting, 6937 ft.; raising, 2614 ft.; intermediate work, 4456 ft.; total 14,341 ft., compared with 15,665 ft. in 1914. The cost of concentrating was $1.215 per ton, compared with 93.2 cts. in 1914. The increase in cost was caused by heavy repair work and flotation expense. The total mill recovery was 85.27 per cent., compared with 73.55 per cent. for the previous year. The grade of ores treated by the concentrator for 1914 and 1915 is given in the following table:

	1914		1914	
	Dry Tons.	Per Cent. Cu.	Dry Tons.	Per Cent. Cu.
Company ore	32,560	3.72	30,101	4.69
Custom ore	140,486	4.48	121,792	4.67
Total and average	173,046	4.34	151,893	4.67

The smelting cost was $2.755 per ton for 206,549 tons of charge smelted, against $2.669 for 207,595 tons smelted in 1914. The increase was due to labor, repairs and flux costs. Coke costs decreased 6 cts. per ton of charge. The converting costs and production compare as follows:

	1915.	1914.
Cost of converting per ton fine copper	$5.36	$5.65
Pounds blister copper produced	27,960,091	30,448,901
Pounds fine copper produced	27,736,158	30,210,361

The report of the Arizona Copper Co. for the year ended Sept. 30, 1915, showed a production of 37,416,910 lb. of copper. Total ores mined from the company's property during the year amounted to 968,566 dry tons, the yield as indicated by the smeltery returns on ore treated, 39.23 lb. of copper per ton of ore, an increase of 3.06 lb. per ton as compared with the previous year. Operations were interfered with in the early part of the fiscal year by the European war and later by the strike of miners. Both conditions have been remedied in so far as the company is concerned, and operations are continuing.

The Miami Copper Co. operating at Miami, Ariz., produced 17,575,-879 lb. of copper in the first half of 1915 and 24,256,180 lb. in the second half, making a total of 41,832,059 lb. derived from 1,348,142 tons of ore. The total profits were $3,408,562, or $4.56 per share, of which $2.25 was disbursed in dividends. The operations of the company during 1915 were a distinct achievement, for although the ore carried 0.11 per cent. less copper than in the previous year, the yield was 0.7 lb. of copper higher per ton of ore, the mill extraction having been raised from 69.93 per cent. to 75.17 per cent.

No additions to the ore reserves were made during the year. On Jan. 1, 1916 the reserves were 18,140,000 tons of ore containing 2.40 per cent. copper, 17,000,000 tons at 1.21 per cent. copper and 6,000,000 tons of mixed sulphide and oxide ore containing 2 per cent. of copper. Prospecting has been resumed to increase the tonnage, but no new calculations have been made as a result of recent drilling operations.

Costs of milling the ore amount to a total of $0.57940 per ton, up to the point of placing the concentrates on the cars for shipment. During the year there was milled 1,348,122 tons of ore carrying 2.17 per cent. copper, resulting in 52,539 tons of concentrates containing 44,033,761 lb. of copper, or 41.91 per cent. The total cost of refined copper in concentrate on board cars at Miami was $1.8785 per ton of ore. From the above concentrates the smelter returns of refined copper amounted to 41,832.059 lb. of copper.

The Shattuck Arizona Copper Co., Bisbee, Ariz., reports a production of 11,154,211 lb. of copper together with values in gold, silver, and lead. 90,481 tons of dry ore were removed from the stopes of the mine, and a small amount of ore resulted from development work, making a total of 95,570 tons of ore produced. Most of this ore was shipped, and resulted in the production of 117.92 lb. copper per ton of ore. The average price received for copper was 17.312 cts. per lb. on 8,622,358 lb. sold, and the total receipts were $2,368,547 principally from the sale of ores. The company paid $875,000 in dividends during the year.

The Magma Copper Co., Superior, Ariz., reports an operating profit of $670,886 for 1915 and a net profit of $611,729 after charging off $59,-157 for depreciation. The receipts from the sale of metals were $1,023,-

675, and the cost of production was $353,128. Balance of quick assets amounted to $442,445 exclusive of mine and mill supplies on hand. Dividends No. 1 and No. 2 were paid, amounting to $240,000. The copper production was 6,046,459 lb., and after crediting gold and silver, the average cost was 6.82 cts. per lb. The average selling price was 17.91 cts. per lb. The following table gives details of ore production and ore reserves:

ORE PRODUCTION

	Tons	Copper, Per Cent.	Silver, Ounces.	Gold.
Mined	46,691	6.43	7.45	.....
From dump	12,528	4.62	5.00	.....
Total treated	59,219	6.05	6.93	.....
Crude sorted	3,756	18.44	20.09	$1.58
Mill heads	55,463	5.21	6.04	.....
Concentrates produced	15,039	16.67	19.05	$2.18
Carbonate ore	900	8.20	4.55	$1.20

ORE RESERVES

	Tons.	Copper, Per Cent.	Silver, Ounces.	Gold, Ounces.
Reasonably assured sulphide ore	87,000	6.72	6.80	0.03
Ore in third-class dumps	3,000	4.85	5.48	0.02
Total	90,000	6.55	6.75	0.029

	Tons.	Zinc, Per Cent.	Lead, Per Cent.	Silver, Ounces.
Lead-zinc ore, probable	10,000	14.0	4.0	10.0

No carbonate ore is included in the reserve. The company owns 346 acres of mining claims and 133 acres of mill sites.

The recovery at the mill was 86.765 per cent. of the mill feed, and 89.324 per cent. of the copper contents of the mine-run of ore was treated by hand sorting and milling. The property is equipped with a 200-ton mill and an oil-flotation plant. It has a three-compartment shaft to the 1200-ft. level and an electric hoist capable of working to 2200 ft. in depth.

The Superior & Boston Copper Mining Co., Globe, Ariz., for year ended Sept. 30, 1915, received from all sources $73,638 and spent $103,-394, leaving a balance on hand of $29,529 as compared with a balance of $59,285 on Oct. 1, 1914. The mine produced ores to the value of $96,-695 during the year, of which $42,164 was produced by leasers. Development work consisted of 1457 ft. of drifts and crosscuts and 637 ft. of raises. The company owns 800 acres adjoining the Arizona Commercial and United Globe properties on the east, which is fully paid for. A program for the development of sulphide ores at and below the 1200-ft. level has been definitely outlined for 1916. The production to date amounts to a little over $1,500,000 from oxidized ores mined in the upper levels.

According to the annual report of the Calumet and Arizona Mining

Co., the production of fine copper in 1915 amounted to 65,268,910 lb. of which 63,126,931 lb., came from company ores and the rest from purchased materials. The total earnings of the company were $11,683,-724.13 and the net income was $5,453,881.51.

California.—During 1915 California enjoyed a prosperous year in the production of 37,658,444 lb. of copper as compared with 29,784,173 lb. the previous year.[1] This might have been even greater had it not been for the litigation between the farmers and smelting interests of the State which has hampered production for several years past. In Shasta County the farmers were again denied their petition to the court against the Kennett smelter belonging to the Mammoth Copper Co., and continuous operation of the smelter was not interrupted. The farmers have, however, kept the Balaklala smeltery from resuming operations and in order to avail themselves of the high prices now offered for copper the Balaklala Co. has entered into a contract with the Kennett smeltery for the treatment of 300 tons of ore daily for the next 10 years.

The Mammoth Copper Co. completed purchase of the Friday-Lowden and other mines in close proximity to its Mammoth property, and began the driving of a lower tunnel to develop the Mammoth ore-bodies at a depth of 400 ft. below the lower, or No. 5, level. The tunnel will be 5000 ft. long and will cost in the neighborhood of $100,000. A sorting plant was erected near the Mammoth mine for separation of the high-grade zinc ore from other mine product, and heavy shipments of zinc sent to eastern smelters. The year marked the first time the company ever turned its zinc ores to profitable account, and the value of the output is placed at over $1,000,000. Three blast furnaces were operated constantly. The company was very active in developing its Stowell, Spread Eagle and other properties, and the work of the year is stated to have been highly satisfactory. In addition to ranking first in production of copper, zinc and silver, the Mammoth Co. yielded much gold and some lead. The Balaklala Copper Co. resumed production in the early summer, sending its output to the Kennett smelter. Much development work was accomplished and mine equipment placed in shape for service. Toward the close of the year it was reported a merger was being perfected whereby the Balaklala, Trinity and several smaller properties would be acquired by a $50,000,000 corporation. The Mountain Copper Co. treated a large tonnage at its concentrating plant, employing flotation, near Keswick, and maintained heavy shipments of selected ore to the Martinez smelter. The Greenhorn Copper Co. was formed and started shipments to the Kennett smelter. Work was prosecuted at the Shasta-Belmont and other small mines. The Bully Hill

[1] Advance Statement, U. S. Geol. Surv.

Copper Co. continued experiments with a process for treatment of its zinc-copper ores, and it was reported that the management had practically decided on the early erection of an electrolytic zinc plant.

Production of copper made rapid strides in Plumas County, due to extensive developments on the Plumas copper belt. The Engels Copper Co., operating near Taylorsville, doubled the capacity of its flotation plant and shipped heavily. Mine developments were highly satisfactory, resulting in blocking out of large reserves of good ore. The company also surveyed a route for a branch railroad from its mine, and preparations were made to build the line to either Westwood or Keddie. Electric power was brought in and all mine and mill equipment is electrically impelled. The Walker Copper Co. erected a 100-ton concentrator in the Portola district, and constructed an aërial tramway from mine to plant. Underground work resulted in development of a large tonnage of profitable ore. The company is controlled by Salt Lake people. The Genesee Valley and other companies were active, and prospects are good for the building of at least one concentrator in 1916. The Novak, near Doyle, was prepared for a concentrator.

Calaveras County remained second among the copper producers, with a good year registered by the Penn Chemical Co. and Calaveras Copper Co. The Penn Chemical Co. operated its smelter at Valley Springs steadily, despite determined efforts of the farmers to close it. A heavy tonnage of high-grade ore came from the Campo Seco mines, a considerable amount being used in the manufacture of chemicals. The Calaveras Copper Co. recorded an excellent season. The concentrator was operated steadily, and large quantities of rich ore also sent to custom smelters. Developments in the lower workings of the mines at Copperopolis uncovered new ore-bodies, with portions carrying ore of high grade. Improvements were made to the plant, and it was reported steps had been taken for important additions to the concentrator in 1916. It is estimated the copper output of the county for the year approximated 6,600,000 lb. compared with 4,468,998 in 1914.[1]

Idaho.—The production of copper in Idaho in 1915 amounted to over 7,365,000 lb., as compared with 5,178,000 lb., in 1914.[2] As heretofore, the bulk of the output came from Custer County, credited with producing 6,195,000 lb. during the past year. The mines in Shoshone County produced approximately 1,000,000 lb. while those of Adams and Lemhi Counties produced 120,000 and 50,000 lb. respectively.

In the Mullen district the most important development is the National property which has recently resumed mining and milling operations.

[1] *Min. Eng. World*, Feb. 5, 1916, p. 293.
[2] Mining Industry of Idaho, 17*th Ann. Rept.*, pp. 133–134.

The first two cars of concentrates were shipped late in December. The Wilfley table concentrates run from 95 to 100 oz. silver and 10 per cent. copper, while the flotation extraction from the Wilfley tailings runs 50 oz. silver and 10 per cent. copper. The problem at this property is to treat a large body of low-grade ore, and recent successes in mining and milling methods point to an early solution and a prosperous period for the company.

The Missoula Copper Co. has recently secured patents to a large group of claims adjoining the National mine on the north, and will probably do some important development work this coming season. The property has partly developed a large ore-body similar in character to the National.

The Snowstorm Co., one of the largest copper producers in the district, closed down both mine and mill during the year with the announcement that they had reached the limit of their ore channel. Some development work has recently been resumed, however, but of what nature has not been made public.

The Reindeer-Queen property is the next copper mine in the line of development work and ore showing. This company has developed a large ore-bearing channel for over 1000 ft. The ore is chalcopyrite in spathic iron gangue, concentrates running over 30 per cent. copper.

On the same belt east of the Reindeer-Queen is the Richmond property owned by Chas. Heidenreich and associates of Spokane, which has been shipping steadily during most of the year, the ore carrying 30 per cent. copper and considerable gold. On the same vein the St. Lawerence property, owned by Angus Sutherland and associates of Wallace, has been shipping ore steadily during the summer. Both properties are old locations, but have never before produced to any extent. One peculiar feature of the ore is the presence of free gold in the carbonates near the surface. On the Richmond during December the company opened the vein in a lower tunnel, where a full tunnel face of 30 per cent. ore is reported.

On the west end of this copper belt the ore has been found as far west as Place Creek, south of Wallace, where the Castle Rock Co. has opened a vein and shipped during the year several cars of ore averaging 10 per cent. copper.

In a new copper belt lying north of Saltese several miles, the Black Traveler Co. is developing a copper silver vein at considerable depth by tunnel. Drifting has been done on the vein for some distance and shows from 2 to 3 ft. of copper ore that averages about 5 per cent. with low silver values. This company has another and larger vein some distance north which is covered on the surface with an immense iron capping some 40 or 50 ft. in width, and it is the intention of the company to open this vein from the lower tunnel.

On the Little North Fork, Andy Delvin and Al Page and associates have opened a new copper property and shipped several cars of ore, and are now erecting a concentrator plant at the mine, claiming to have a large tonnage of ore running about 5 per cent. copper.

Central and Southern Idaho has shown marked activity and progress in ore production during the past year, according to State Mine Inspector Bell. This is particularly true of the copper ore deposits of the Empire Copper Co. at Mackay, whose management continued extensive leasing system, with a shipping record of several thousand tons a month. The adit on this property, now exceeding 4000 ft. in length, has recently penetrated the ore-bearing formation and while no crosscutting had been done at the time of a recent visit to the property, the geological conditions so far encountered were normal and promising for the successful intersection of the ore at the new level 900 ft. deeper than the productive horizon at the 700-level of the mine where ore resources and prospects are in better shape at this time than at any period in the history of the enterprise.

Quite a little activity was displayed in copper development in the Seven Devils belt northwest of Boise and several small shipments of rich mineral was made as a result. This is a most widely mineralized copper district. Transportation troubles have been, and still are, its chief drawback. It is safe to predict a future of no small importance for this region in copper ore production.[1]

Michigan.—The production of copper in Michigan during 1915 according to the Advance Statement of the U. S. Geological Survey amounted to 238,956,410 lb. as compared with 158,009,748 lb. in 1914. In the accompanying table is given the production of fine copper of the most important companies compiled with their annual reports, with the exception of a few whose statements are not as yet available, in which cases estimates are offered.

DIVIDENDS PAID BY MICHIGAN MINES

Mine.	1913.	1914.	1915.	Mine.	1913.	1914.	1915.
Calumet & Hecla	$3,200,000	$1,000,000	$5,000,000	Quincy...	$412,500	$55,000	$880,000
Copper Range Con..........	1,082,700	....	1,182,003	Tamarack.	....	....	....
Mohawk........	500,000	100,000	....	Wolverine	300,000	240,000	....
Osceola.........	1,009,580	288,450	1,057,650	Totals....	$6,504,780	$1,683,450	....

There was mined and milled in the Lake Superior district 12,334,699 tons of ore-producing concentrates, containing 265,283,378 lb. of copper,

[1] *Min. Eng. World*, Feb. 5, 1916, pp. 307–309.

or a recovery of slightly above 1 per cent. of copper from the ore. A portion of the concentrates produced was not smelted in 1915.

COPPER PRODUCTION IN MICHIGAN
(Pounds of fine copper)

Mines.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Adventure...	1,244,872	90,870	*Nil*	*Nil*	*Nil*	8,727,312	....	....	....
Ahmeek.....	5,527,672	6,280,241	9,198,110	11,844,954	15,196,127	16,455,769	9,220,874	13,643,605	21,800,492
Allhouez....	2,934,116	3,047,051	4,031,532	4,655,702	4,780,494	5,525,455	4,091,129	6,056,548	10,043,459
Atlantic.....	*Nil*	*Nil*	43,483	19,018	*Nil*	*Nil*	44,370	....	....
Baltic.......	16,704,868	17,724,854	17,817,836	17,549,762	15,370,449	13,373,961	7,736,124	7,001,945	12,028,947
Cal. & Hecla.	88,055,723	81,660,723	74,593,553	72,672,469	72,861,925	67,856,429	45,016,890	53,691,562	*a*71,000,000
Centennial...	2,373,572	2,196,377	2,583,793	1,572,566	1,493,834	1,742,338	1,612,262	2,287,532	2,347,500
Champion...	16,489,436	17,786,763	18,005,071	19,224,124	15,639,426	17,225,508	12,080,592	15,807,206	33,407,599
Franklin	4,401,248	3,703,421	1,615,556	966,353	820,203	1,710,651	1,021,440	93,283	1,314,969
Isle Royale..	2,667,608	3,011,664	5,719,056	7,567,399	7,490,120	8,186,957	4,158,584	6,593,451	9,342,106
Mass........	2,078,677	1,766,930	1,723,436	1,321,885	1,326,898	2,045,006	1,213,545	2,944,952	4,638,452
Michigan....	2,665,404	3,000,206	1,979,305	36,682	327,773	300,000	....	....	....
Mohawk.....	10,107,266	10,295,881	11,248,474	11,412,066	12,091,056	11,995,598	5,778,235	11,094,859	15,882,914
Osceola......	14,134,753	21,250,794	25,296,657	19,346,566	18,388,193	18,413,387	11,325,010	14,970,737	19,731,472
La Salle.....	....	....	....	....	....	....	287,200	540,731	*a* 700,000
Quincy......	19,796,058	20,600,361	22,511,984	22,517,014	22,252,943	20,634,800	12,184,128	15,356,380	22,045,813
Superior	....	21,244	1,789,315	3,181,041	3,236,233	3,921,974	2,992,765	3,217,635	4,000,000
Tamarack...	11,078,604	12,806,127	13,533,207	11,063,606	7,494,077	7,908,746	4,168,743	1,074,808	3,888,150
Trimountain	8,190,711	6,034,908	5,282,404	5,694,868	6,120,417	6,980,713	4,990,938	5,048,306	8,302,896
Winona.....	1,285,863	*Nil*	*Nil*	*Nil*	*Nil*	2,307,237	1,448,737	1,352,084	1,732,638
Wolverine...	9,273,351	9,555,233	9,971,482	10,469,253	9,630,639	9,408,960	1,550,000	3,435,459	*a* 7,400,000
Victoria.....	1,207,237	1,290,040	1,164,564	1,164,564	1,303,331	1,224,911	4,488,000	1,486,242	1,499,695
Others......	100,000	....	2,862,233	899,647	294,873		....	....	....
Totals	220,317,041	222,123,688	230,971,051	223,179,539	216,119,011	225,945,712	135,409,566	165,697,325	252,097,102

a Estimated as given in *Min. Sci. Press*, Jan. 8, 1916, p. 63.

"The year 1915 closed with the mines of the Lake Superior copper district working to greater capacity than at any other time in their history. The first quarter of the year was taken up in getting the mines back to normal after the enforced curtailment brought about at the outset of the European war. Wages were returned to their original scale, and at some properties they were increased. The Calumet & Hecla Mining Co. returned to all employees, in the form of a bonus, the difference in money between the reduced scale of wages and the original scale, based on the actual number of days worked during the time the reduction was in effect. All the smaller properties that suspended operations at the outbreak of the war resumed, and the larger properties took on all the available men, so that the labor situation was cleaned up and the district was very prosperous.

"The Keweenaw Copper Co. carried on development work on the Ashbed lode at the Phœnix property and opened some very encouraging ground. The Ahmeek Mining Co. put No. 3 and No. 4 shafts into regular commission and started two new heads at the stamp mill to take care of the increased tonnage. A low-pressure steam-turbine generating outfit was also started at the mill. The Allouez Mining Co. rounded into shape nicely during the year and was put on a dividend-paying basis.

"The Osceola Consolidated Mining Co. completed the erection of a new rockhouse at No. 3 shaft of the old mine, and after being idle for several years, this shaft was again opened. During the later months of the year, a material betterment was noted in the copper contents of the rock. The La Salle Copper Co. resumed operations at both its shafts. The production was small, for considerable development work was done. The New Arcadian succeeded in developing an encouraging formation which offers well for the future of the property. About 3,500 tons of rock was shipped to the stamp mill for three separate mill tests, and it ran better than 20 lb. copper to the ton. The rock was taken from the development openings without any selection.

"The Hancock and Quincy companies made an exchange whereby the former secured the use of No. 7 shaft of the Quincy for a portion of each day for the handling of rock from the lower levels, which were extended from the Quincy shaft into the Hancock property.

"The stamp mill of the Isle Royale Copper Co., which was destroyed by fire on Christmas eve of 1914, was reconstructed and put in commission during the summer. The mill contains three compound heads and a low-pressure turbo-generating outfit that furnishes the necessary power for operating the washing machinery and the main pumping station. The South Lake property carried on development work and started the erection of the permanent rockhouse. Some small shipments of rock were made to the Franklin Mill.

"At the Lake property, operations were resumed. At the close of the year some fine ground was being developed and the management was most optimistic regarding the ultimate success of the property.

"The success of the White Pine Copper Co., a subsidiary of the Calumet & Hecla Mining Co., developed a keen interest in the possibility of the Porcupine Mountain district of Ontonagon County. The White Pine Extension Co. started exploratory work with diamond drill and shaft sinking. A formation was opened which will be thoroughly developed.

"The equipment of the White Pine Copper Co., which consists of a 1000-ton mill, power plant and compressor house and rock-transportation system, was put in commission in the early part of the summer and the property put on a permanent producing basis. The two shafts were equipped with permanent hoisting and rock houses. Buildings and equipment and a number of substantially built dwellings were erected for the employees. Railroad connections were made with the Chicago, Milwaukee & St. Paul R. R., and the camp is in a most flourishing condition.

"Fire destroyed the shafthouse at the No. 2 shaft of the Centennial Copper Co. and caused a curtailment in the production. The Mohawk Co. had a successful year; the mine was put in A1 shape, and costs were materially lowered.

"Work was resumed at the Tamarack mine. An examination was made of the property for the minority stockholders and a valuation of the property was made with a view of selling the entire stock to the Calumet & Hecla Mining Co. A proposition was made to the directors, but no definite action was taken. At the stamp mill, plans were laid for the construction of a reclamation plant for the re-working of the tailings piles. A building for this work was erected last year, but all other work was stopped at the beginning of the European war.

"At the Calumet & Hecla Mining Co. the No. 2 re-grinding mill, together with the hydraulic dredge and classifying house, was put into regular commission, and the results obtained from the re-working of the tailings piles more than met the expectations of the management. The building of the new leaching plant was constructed, all contracts for the necessary apparatus were closed, and the plant will go into commission during the summer of 1916. Ground was broken for the erection of the third large furnace at the smelting works. Both branches of the mine were worked successfully and kept the stamp mills working to their utmost capacity."[1]

Montana.—The copper output of Montana during 1915 according to the U. S. Geological Survey's advance figures amounted to 268,263,040 lb. as compared with 236,805,845 lb. for the previous year, and 285,719,-

[1] The Lake Superior District, C. L. C. Fichtel. *Eng. Min. Jour.*, Jan. 15, 1916.

918 lb. in 1913. During the first quarter the large producers were operating on a reduced basis the same as in the latter part of 1914, but with the restoration of steady conditions in the demand for copper normal production scales were resumed by the different companies.[1]

The year 1915 has witnessed the most remarkable revival and advance in mining operations in Butte and the Butte district in the history of Montana. Practically every mining property in Butte is operating at capacity at the present time. On Jan. 1, 1915, only 12 of the 22 operating shafts of the Anaconda Copper Mining Co., in Butte, were running. They were on a five-day-a-week schedule, with 5200 men employed, and the daily output was 7500 tons of ore. At the present time there are 10,500 men employed in the Butte mines of the Anaconda Co. All of the 22 operating shafts are hoisting ore with a total daily tonnage of 13,600 tons. This will be increased to 15,000 tons of ore per day after Jan. 1, when the improvements at the Washoe smelter will enable the company to handle the increased output.

The report of the Anaconda Copper Mining Co. for 1915 has been issued and forms an interesting record of the company's activities. Development in the mines amounted to in total 35.31 miles of work, as compared with 33.15 miles in 1914. Shafts at the different properties were sunk to additional depths aggregating 4980 ft. Development shows satisfactory results, particularly on the lowest levels, where the ore-bodies show, on the whole, no diminution in size or metal-content, and in many instances show increased size and value. During the year the mines produced 4,376,556 tons of ore and 6783 tons of precipitates.

The reduction works treated 4,421,628 tons of ore and other cupriferous material at Anaconda and 384,065 tons at Great Falls. Of the total, 4,258,129 tons was from the company's mines, 535,223 tons was purchased or treated for other companies, and 12,342 tons of precipitates and cleanings from old works at Anaconda was treated. At Anaconda there was produced 189,483,047 lb. of fine copper, 6,982,822.24 oz. of silver and 75,679.668 oz. of gold. At Great Falls the production was 64,828,527 lb. of copper, 2,022,795.44 oz. of silver and 31,023.08 oz. of gold. Of the total production, 235,076,289 lb. fine copper, 8,064,986.02 oz. silver and 106,702.748 oz. of gold came from the company's mines.

The International smeltery at Tooele, Utah, treated 270,374 tons of copper ore and 395,573.87 tons of lead ore, from which 14,271,174 lb. of copper, 113,002,657 lb. of lead, 5,090,157 oz. of silver and 48,020.361 oz. of gold was produced. The smeltery at Miami, Ariz., started work on May 21, 1915, and has treated during the year 70,303.72 tons of concen-

[1] For an extended account of the mining operations in the Butte district see *Salt Lake Min. Rev.*, Jan. 15, 1916.

trates and 17,104.52 tons of purchased ore, producing 51,769,669 lb. of copper, 69,999.52 oz. silver and 822.179 oz. of gold.

The International lead refinery, at East Chicago, Ind., treated 55,376.49 tons of lead bullion from Tooele and 2266.06 tons of foreign ore, producing 103,121,355 lb. of common and corroding lead, 9,164,073 lb. of antimonial lead, 4,031,610.09 oz. of silver and 18,135.6 oz. of gold. The refinery of the Raritan Copper Works, at Perth Amboy, N. J., treated 162,282.48 tons of copper bullion and 719,342.75 oz. of silver bullion, producing 323,850,718 lb. of fine copper, 16,025,993.18 oz. of silver and 174,407.776 oz. gold.

The report of the North Butte Mining Co., Butte, Mont., for 1914 shows a production of 18,421,761 lb. of copper, 1,092,300 oz. of silver and 1107 oz. of gold. These metals were produced from 337,372 dry tons of ore and 43 dry tons of precipitates. The following sales of metals were made during the year: 21,868,479 lb. of copper at 13.7436 cts. per lb.; 1,377,297 oz. of silver at 55.881 cts. per oz., and 1107 oz. of gold at $20 per oz. During April and May a leaner grade of ore than had heretofore been mined was encountered, and following good mining practice, it was necessary to extract and treat this ore. This, together with labor troubles at Butte and the reduction of output at the beginning of the war, was the cause of a decrease in production as compared with 1913. The cost of producing copper was 11.505 cts., as shown by the following table:

COST PER POUND OF COPPER

	Cents.
Mining and development	7.424
Construction	0.016
Freight on ore	0.224
Concentrating, smelting, freight on bullion, refining, selling, etc.	6.879
General miscellaneous expense and taxes	0.257
Total	14.800
Less value of gold and silver and miscellaneous income	3.295
Net cost	11.505

The mine shipped 343,314 tons of wet ore and 71 tons of precipitates. The mine was operated 309 days, with an average of 767 men. An average of 1111 tons was hoisted per day. The financial statements show that $358,215 was made as profit and that dividends aggregating $635,000 were paid.

The Butte & Superior Copper Co., of Butte, Mont., has issued its report covering the year 1915, showing an increase in the net income of $7,708,820 over the preceding year. The report gives the following figures: Total net income for the year ended Dec. 31, 1915, was $9,125,-947, as compared with $1,417,127 for the year 1914. Earnings in 1915 were equal to $33.47 a share on the 272,697 shares outstanding.

Ore milled for the year amounted to 522,300 tons. The total contents of each metal is shown in the following tabulation: 7,361,517 oz. gold; 3,985,090 oz. silver; 2,215,313 oz. copper; 12,667,964 lb. lead; 177,802,719 lb. zinc.

The total production of zinc concentrates was 152,897 tons which contains the following totals of metal: 6,163,677 oz. gold; 3,385,164 oz. silver; 191,751,545 lb. copper; 7,485,498 lb. lead; 163,956,971 lb. zinc.

The production of lead concentrates amounted to 5274 tons and the content of metal was as follows: 286,034 oz. gold; 178,218.38 oz. silver; 40,665 lb. copper; 3,988,679 lb. lead; 1,426,130 lb. zinc.[1]

Nevada.—The output of copper in Nevada during 1915 increased from 60,122,904 lb. in 1914, to 67,757,322 lb.,[2] due chiefly to the great activity in the Ely district where the scale of operations was considerably enlarged late in the year. Prospecting was carried on vigorously under the stimulus of the prevailing high prices in regions known to contain copper deposits, and a number of good prospects were opened up in the Cuprite district, and at Jackson Mountain, Esmeralda County, in the Luning district, Mineral County, and in an extended mineral belt seat and north of Golconda, Humboldt County. Development work continued on copper properties of the Yerrington district, though the smelter at Thompson remained closed during the year. The Rea property at Jackson Mountain was sold to copper operators after large bodies of copper ore of good grade had been exposed. At Cuprite, claims aggregating 900 acres were purchased by representatives of Senator W. A. Clark, and active prospecting was started at once. This property is regarded as particularly desirable to the Clark interests as it lies near the main line of the Las Vegas and Tonopah railroad, owned by Mr. Clark.[3]

The annual report of the Nevada Consolidated Copper Co., Ely, Nev., states that the total profits from all operations were the largest by far that have been obtained for any one year since the beginning of operations.

The net profit for the year available for dividends amounted to $5,905,601, or $2.95 a share; of this $1.50 a share, or $2,999,185, was paid in dividends, $347,486, or 17 cts. a share, was used for ore extinguishment and depreciation, and $2,558,929, or $1.28 a share, was added to earned surplus. The December dividend payment brings total dividend disbursements up to $17,976,436, and there remains in earned surplus account $4,849,555. In addition to the dividends from earnings, $1,999,457 has been returned to stockholders from surplus account, making the total payment to stockholders to Dec. 31, 1915, $19,975,893.

From the beginning of operations to Dec. 31, 1915, there have been

[1] *Salt Lake Min. Rev.*, Apr. 30, 1916, p. 19.
[2] Advance Statement, U. S. Geol. Surv., May, 1916.
[3] *Min. Eng. World*, Feb. 5, 1916.

sold by the company 391,593,615 lb. of copper at an average price of 14.128 cts. per lb.; total realized value, $55,324,810.

Work with churn drills was continued during the year on the Ruth, Eureka, Liberty and Hecla groups. On the Ruth group were drilled 17 holes, totaling 9092 ft., and in the pit areas 23 holes, totaling 8678 ft., or a total for both localities of 40 holes, aggregating 17,779 ft. The total as of present date amounts to 381 holes with a footage of 124,316 ft.

Considerable tonnage has been added to the ore reserves, which, as was the case in the preceding year, was greater than the amount extracted by mining operations during the year. The increased tonnage is due to new ore of good grade developed in the Ruth mine, some increased tonnage in the Eureka, and to including certain low-grade tonnage which previously had not been considered of payable grade, but which improved costs in mining, milling and smelting have shown to belong in the category of payable ore. The total of recoverable ore remaining Dec. 31, 1915, was 50,525,289 tons averaging 1.652 per cent. copper.

During the year active mining operations were started in the Ruth mine by the caving system, and since June, 86,029 dry tons of ore have been shipped to the concentrator, averaging 2.28 per cent. copper. No mining during the year was carried on in the Veteran. Steam-shovel operations were carried on in the Eureka, Hecla and Liberty pits. The major portion of the ore was taken from the Liberty and Hecla. Owing to the favorable financial conditions and the increased demand for copper the ore production was greatly increased during the year 1915, the tonnage mined being 16.73 per cent. more than in the previous year.

Siliceous carbonate ore amounting to 26,258 dry tons and averaging 3.48 per cent. copper, was crushed and delivered to the smeltery. All of this, with the exception of 1083 wet tons mined in the pit during the year, was taken from the storage piles at the mine.

The number of cubic yards of capping removed for the year was 9.41 per cent. less than in the previous year, and stripping is now well ahead of requirements. The yardage removed during the year from the Eureka ore-body was 108,646 cu. yd.; Liberty-Hecla, 2,649,704 cu. yd.; total, 2,758,350 cu. yd.

The total yardage removed to Dec. 31, 1915, is 17,675,637; the remaining stripping to be done lies mainly in the grade slopes. The amount of stripping annually from now on should be greatly reduced, though the reduced expenditures for this will be partly offset by expenditures required for thoroughly opening up the Ruth mine.

The direct mining cost by steam shovel for the Eureka, Hecla and Liberty pits was 15.24 cts. This shows a very slight increase over the year 1914, which was 15.17 cts. This figure includes charges of all kinds, such as labor, supplies, repairs, management, taxes, and a proper proportion of New York and Nevada overhead charges. Tax charges alone, including Federal, property and bullion taxes, all charged against mining, amounted to about 0.2 ct. per lb. of copper produced, or 4 cts. per ton of ore mined.

Stripping costs show a reduction compared with those of 1914, being for the year 1915, 28.87 cts. per cu. yd. as against 31.71 cts. for the year 1914.

Cost of mining carbonate ore was 46.1 cts. per wet ton, as against 62.9 cts. per wet ton in the year 1914.

In addition to the treatment of the Nevada Consolidated ores, a considerable tonnage of custom ore from the mines of the Consolidated Coppermines Co., amounting to 91,732 dry tons, was handled. As was the case during the year of 1914, this was mined with the Nevada Consolidated Copper Co.'s steam shovels and concentrated and smelted at the company's plant.

The ratio of concentration was a little more favorable, being 6.05 in 1914 and 7.18 in the year 1915.

The number of pounds of fine copper in the blister produced for the fiscal year was 64,305,866, of which 1,785,011 lb., was from custom ore.

The costs per ton of blister copper produced, for 1915 were $9.76, a great improvement over those for 1914 and the lowest obtained since the converters were blown in. The grade of matte, 27.2 per cent., was considerably lower than that for any other year since operations began, the highest being 44.6 per cent. for the year 1910.

The yield for the year 1915 of sulphide ore mined and treated and from siliceous carbonate ore delivered to the smelter was 62,726,651 lb. of fine copper. The average cost per pound of copper was 8.67 cts. and deducting miscellaneous earnings this is reduced to 8.23 cts.

The report of the Mason Valley Mines Co., Yerrington, Nev., for the year ended Dec. 31, 1915, shows that, since discontinuing operations in October, 1914, it has not been considered for the best interest of the company to resume mining and smelting operations until such time as a sufficient and satisfactorily supply of other ores could be arranged for so as to derive the greatest benefit from the Mason Valley ores.

Few people have appreciated the increase in the assets of the Consolidated Coppermines Co. at Kimberly, Nev., resulting from the drilling campaign inaugurated by the new management late in 1913. Summarized, the reserves reported to the officers of the company by Manager E. F. Gray are as follows:

	Tons.	Per Cent. Cu.
Developed by churn drilling—sulphides	14,954,368	1.129
Developed by churn drilling—carbonates	998,529	1.720
Developed by underground work—sulphides	1,000,000	1.670
Total developed	16,952,897	1.19
Partly developed—sulphides	8,448,412	1.006
Total developed and partly developed ore[1]	25,401,309	1.131

The Consolidated Coppermines Co. now controls the old Giroux Consolidated Mines Co., the Butte & Ely Copper Co., the New Ely Central Copper Co., the old Coppermines Co., the Chainman Consolidated Copper Co., as well as miscellaneous small groups of claims designed to give approaches to steam-shovel pits, water rights and otherwise round out the property.

New Mexico.—During the year 1915 New Mexico produced 62,817,-234 lb. of copper,[2] as compared with 64,204,703 lb. the previous year, which is a slight decrease considering the large increase made in 1914 of 30 per cent. Most of the output of the State comes from the operations of the Chino Copper Co., in the Santa Rita district.

The annual report of the Chino Copper Co. states that no extensive improvements were made or were necessary at the mines. The total amount of ore and waste moved by the steam shovels during the year was 4,480,025 yd. of material in place. Of this amount 2,600,271 tons was ore, the most of which was sent to the mill for treatment. For the 12 months the mill averaged 6520 tons per day, treating a total of 2,379,800 tons which is the largest amount handled in any one year since the beginning of operations. The average content of the ore treated during the year was 2.155 per cent. copper, and the total production of concentrates was 158,444 tons, containing 68,293,893 lb. of copper which corresponds to an average of 21.551 per cent. copper and a recovery of 28.697 lb. of copper per ton of ore. This represents an extraction of 66.588 per cent. of the copper-content. The ratio of concentration and the grade of concentrates were both higher than in the previous year due to improvements in the concentrate-recleaning plants that were in service throughout the year.

The average cost of net copper produced from the concentrates was 7.12 cts. per lb., as compared with 7.6 cts. in 1914. The per-pound cost as stated includes charges of every nature except depreciation. If miscellaneous earnings for the year were credited to the cost of producing copper, the net cost of all copper, based as stated, would be 6.75 cts. as compared with 7.35 cts. for the previous year.

Developments for the year resulted in an increase of positive and indicated ore fully equivalent to the quantity mined, leaving practically

[1] No allowance is made for ore known to exist in the territory served by the Old Glory, Taylor, Giroux and Alpha shafts, which are inaccessible except on the 770- and 1000-ft. levels of the Giroux shaft.

[2] Advance Statement, U. S. Geol. Surv.

unchanged the ore-reserve figures of the last report, 90,000,000 tons of an average grade of 1.75 per cent. copper.

Six additional mining claims were located during the year making a total of 153 mining claims comprising 2734 acres.

The net operating profit of the Chino Co. amounted to $6,688,729; miscellaneous income was $229,073, making a total of $6,917,802. Deducting interest paid during the year leaves a net profit applicable to dividends or capital purposes of $6,919,983, or $7.95 per share, as compared with $3.70 per share for the year 1914. Dividends of $3 per share were paid in several installments during the year, aggregating $2,609,860. The dividends paid up to and including 1915 are $6,697,995.

The development and construction campaign of the Burro Mountain Copper Co. is nearing completion. Superintendent E. M. Sawyer, in his annual report, states that the first 500-ton section of the concentrator should be ready for service about Mar. 1, 1916, and construction work designed to facilitate ore extraction in the mine was also about completed. The central power station of 2000-hp. capacity has been finished and tested. Two 1000-hp. Diesel engines are installed in this plant, and these are to be augmented in the near future by a third of the same design, made by the Nordberg Manufacturing Co. The townsite at Tyrone, N. M., is rapidly assuming the appearance of a model town, with hospital and other semi-public buildings carefully grouped and planned under the direction of a New York architect, and about 21,000 ft. of new roads were finished last year.

Churn-drill prospecting was continued through 1915, carrying out the general scheme for testing the large northeastern group of mining claims by a series of holes placed at wide intervals. Three machines were in use, and 20 holes, having an average depth of 1031 ft., were drilled. The general results of this work merely showed the far-reaching extent of the ore-bearing formations, but one hole was drilled through 67 ft. of ore averaging 2.67 per cent. copper. During the year 1,354,377 lb. of copper was produced from various sources, 524,200 lb. being credited to leasers.

The test mill has been partly dismantled, as it has served its purpose in indicating the proper treatment in the 1000-ton plant. A total of 11,008 tons of ore of various types was tested in this mill. In March the work of the mill was concluded, after testing a small unit of the Rork flotation machine, the results being practically the same as those obtained with the Towne machine under similar conditions. Shipments were made to Douglas of about 3000 tons of slime tailings for the purpose of testing by leaching methods.

As the policy of the company was to prepare the mine for ore extraction, extensive mine-repair work was necessary and general development work was subordinated. The ore reserve, however, of Dec. 31, 1915, was equivalent to 130,000,000 lb. of copper, contained in 2,555,000 tons of ore of 2.53 per cent. grade. Duplicate steel headframes and hoisting engines have been installed at No. 2 and No. 3 shafts and concrete shaft collars placed. The Niagara tunnel for ore transportation has been completed, and a 350-ton ore bin constructed above the haulage road, to serve as storage and for loading the 30-ton cars that will be used. The yield of copper from the Lordsburg district was nearly doubled and Oro Grande also contributed an increased yield. The resumption of operations in May, 1915, of the Santa Fe Gold and Copper Co.'s mines and 125-ton matting plant at San Pedro, Santa Fe County (operated only one month in 1914), added a large quantity of copper to the output.

Tennessee.—The output of the State during 1915 was slightly less than that of the previous year, amounting to 18,205,308 lb. as against 18,661,112 lb. in 1914.[1] The entire output comes from the Ducktown district, and is produced by two companies, the Tennessee Copper Co., and the Ducktown Sulphur, Copper & Iron Co., Ducktown, Tenn.

The report of the Tennessee Copper Co. for the year 1915 shows a profit of $1,058,158. Production was 12,750,418 lb. of copper, a reduction of 120,695 lb. from the previous year. Cost was reduced 1.31 cts. per lb. to 10.53 cts. in 1915, although the average yield per ton of ore was only slightly more than in 1914, being 26.83 lb. to the ton, compared with 26.54 in previous year. The average price received was 16.274 cts. per lb., compared with 13.706 cts. in 1914. The income account shows as follows:

	1915.	1914.	1913.
Income	$1,305,021	$810,893	$1,170,159
Charges	62,338	59,000	103,456
Depreciation, etc	184,535	101,126	100,000
Net profit	$1,058,158	$650,767	$966,703
Dividends	600,000	600,000	450,000
Surplus	$458,158	$50,767	$516,703
Previous surplus	1,916,942	1,857,440	2,084,303
Total surplus	$2,375,100	$1,916,942	$1,864,877

Copper production, yield of copper per ton of ore, cost per pound and ore reserves for past 5 years follow:

Years.	Product, lb.	Yield, lb.	Cost, lb.	Ore reserves, tons.
1915	12,750,418	26.83	10.53	5,087,421
1914	12,871,113	26.54	11.83	5,390,661
1913	13,493,140	29.80	11.00	5,534,984
1912	13,252,634	29.80	11.00	5,071,000
1911	13,808,940	31.65	10.88	5,033,000

[1] Advance Statement, U. S. Geol. Surv.

Acid production follows:

Years.	Tons.	Years.	Tons.
1915	210,666	1913	197,713
1914	210,163	1912	192,084

President Wedge says in part: "During 1916 we will profit from the production and sale of nitric acid and other heavy chemicals which are a neutral adjunct to our sulphuric acid manufacture.

"Estimated ore reserves at the close of last year are given as 5,087,421 tons, a decrease of 303,240 tons from the previous year. This takes no account of ore indicated by diamond drilling from the eighth level down, only that actually measured from drifts and crosscuts and decrease is due to the small amount of development work during the year.

"Early in 1915 war conditions affected the fertilizer industry to such an extent that shipments of sulphuric acid were reduced to a point at which the company was unable to operate at capacity and it was decided to build large storage tanks and to arrange facilities for concentrating, as well as to erect plants which would be able to use the acid for making other products. After April the demand for the acid improved and capacity operations ensued for the rest of the year.

"Acid production for the year was 210,666 tons, compared with 210,163 tons in 1914. A plant has been installed which will enable the company at will to introduce nitric acid into the sulphuric process in place of relying upon nitric soda. A considerable portion of the acid produced is being concentrated into oil of vitriol, and a new plant is in process of construction.

"Repairs and replacements at the acid plant are nearing completion.

"During 1915 $1,006,843 was expended for new construction and equipment which included $89,123 on new phenol plant, $212,636 on concentrating plant, $171,453 on a nitrating plant, $58,049 on an oil of vitriol plant and $12,604 on a niter plant.

Utah.—The copper production of Utah during 1915 exceeded that of any previous year, amounting to 175,177,695 lb., as compared with 160,589,660 lb. in 1914, and 148,057,450 lb. in 1913.[1] The total recorded output from the State to the close of 1915 is 1,417,089,532 lb., or about 7.15 per cent. of the production of the United States since 1845. Utah ranks fourth among the States in copper production, having dropped back from third place held in 1914, now held by Michigan. The copper mines of the State are located principally in three districts, Bingham, Tintic, and Beaver, but a number of other districts contribute somewhat to the production of copper. Of the total output of the State, Bingham produces about 93 per cent., and of this nearly 90 per cent. comes from the operations of the Utah Copper Co.

According to the annual report of the Utah Copper Co., the gross production of copper in concentrates for the year 1915 was 156,207,376 lb. After making smelter deductions, the net production amounted to 148,397,006 lb. of refined copper. In addition there were produced 36,760 oz. of gold, for which the company received $20 per oz.; also 371,712 oz. of silver, for which the company received 49.88 cts. per oz.

[1] Advance Statement. U. S. Geol. Surv.

This production of copper, gold and silver was the result of the handling during the year, at both the Magna and Arthur plants, of 8,949,300 tons of ore. The Utah Copper Co. early in the year still curtailed operations. In January only the Magna plant operated, the output being approximately two-thirds of normal; in February the Arthur plant went into operation, when the output was increased to three-quarters of normal; at the end of March both plants were operating at full capacity.

During the year there were milled at the Magna plant 5,233,300 tons of ore, an increase of 771,839 tons over 1914; while at the Arthur plant, 3,261,000 tons were milled, an increase of 1,252,295 tons as compared with 1914. The total ore treated at both plants was 8,494,300 tons, as compared with 6,470,166 tons for the previous year. The Magna plant treated an average of 14,388 tons daily during the year, and the Arthur plant an average of 9563 tons daily during the time it was actually operated.

The average grade of ore milled at both plants was slightly under 1.434 per cent. copper, as compared with about 1.425 per cent. copper for 1914. The average recovery at both plants was 64.13 per cent., corresponding to 18.39 lb. of copper per ton, as compared to 66.04 per cent., or 18.82 lb. per ton, for the previous year. The low extraction was due partly to the presence in the ore of considerable copper in the form of carbonates, but principally to crowding the mills for high production beyond the point of metallurgical efficiency. For the last 6 months of the year the average daily tonnage milled was 26,537, or about 33 per cent. above normal capacity.

The cost of milling at Magna was 30.91 cts. per ton and at Arthur 39.02 cts., as compared with 34.35 cts. and 37.55 cts. respectively for 1914. The average cost of milling at both plants was 34.02 cts. per ton, as compared with 35.36 cts. for the previous year.

The total amount of capping removed during the year was 5,961,367 cu. yd., being an average of 1,490,342 cu. yd. per quarter and an average of 496,780 cu. yd. per month, as compared with an average of 1,427,209 cu. yd. and 475,736 cu. yd. respectively for the previous year. The total amount of capping removed prior to Jan. 1, 1916, was 33,795,410 cu. yd., of which quantity 21,194,751 cu. yd. were from the Utah group and 12,600,659 cu. yd. from the Boston group. At the close of the year the total area upon which stripping operations had been conducted was 203.24 acres, and the actual area completely stripped was estimated at 96.80 acres.

The net operating profit amounted to $15,023,834; miscellaneous income received during the year from outside investments, including dividends received from the Nevada Consolidated Copper Co. and the

Bingham and Garfield Railway Co. and from interest, rentals, etc., amounted to $2,896,609. The total income therefore amounted to $17,920,443. Interest paid during the year amounted to $6962, leaving a net profit applicable to dividends or for other capital purposes of $17,913,481, or $11.03 per share as compared with $5.34 per share for 1914. Dividends paid during the year amounted to $4.25 per share—75 cts. for the first quarter, $1 for the second quarter, $1 for the third quarter and $1.50 for the fourth quarter—aggregating $6,904,082, leaving surplus earnings for the year, after payment of dividends of $11,009,398. The usual amount for depreciation of plants and equipment, being a sum equal to 5 per cent. on the total cost, was set aside and amounted to $546,733. This resulted in passing $10,462,665 to earned surplus account. The total dividends up to and including 1915 are $32,721,897.

1915 Operations.	Utah Copper.	Chino.	Ray.	Nevada Con.	Miami.	Inspiration.
Tons of ore milled.	8,494,300	2,379,800	2,848,969	3,081,520	1,348,122	(*b*)778,851
Tons of ore milled per day.........	(*h*)26,537	(*f*)7,357	(*n*)7,805	(*k*)8,442	(*m*)4,200	(*e*)4,267
Average copper content of ore, %	1.434	2.155	1.673	1.54	2.17	1.702
Average copper content of concentrates, %.....	19.17	21.551	19.293	7.77	41.91	32.67
Ratio of concentration..........	....	15.02	....	7.18	....	24.6
Total pounds copper produced.....	156,207,376	68,293,893	(*a*)62,540,196	(*i*)64,305,866	41,832,059	(*c*)20,445,670
Pounds copper recovered per ton of ore..........	18.39	28.697	21.45	....	....	(*b*)26.4
Extraction, %....	64.13	66.588	64.11	70.18	75.17	79.95
Average milling cost per ton, cents	34.02	(*c*)54.19	50.86	....	....	(*d*)51.585
Average cost of copper per pound, cents............	(*g*)6.612	(*g*)6.75	9.423	7.45	(*g*)6.05	8.132
Ore reserves, tons.	346,315,300	90,000,000	71,911,475	50,525,289	....	....
Copper tenor of ore reserves, %...	1.446	1.75	2.235	1.652	....	....
Dividends paid...	$6,904,082	$2,609,860	$1,872,319	$5,905,601	$1,681,004	....
Added to earned surplus..........	$11,009,398	$4,046,858	$2,084,856	$2,558,929	$3,175,346	(*o*)$600,062
Charged off for depreciation.....	$546,733	$257,265	$301,936	$534,649	$176,213	....

(*a*) Including 1,425,682 lb. produced from ores shipped direct to smelters. (*b*) Six months' production. (*c*) Including 378,360 lb. from oxide ore shipped direct to smelter. (*d*) Including coarse crushing at mine. (*e*) Tonnage for February, 1916, averaged 12,300 per day. (*f*) Average for last 8 months. (*g*) After crediting all miscellaneous income. (*h*) Average for last 6 months. (*i*) Fine copper in blister produced, includes 1,785,011 lb. copper in custom ores. (*j*) F.o.b. cars, Miami; freight, marketing, etc., probably under 1.25 cts. per ton. (*k*) No allowance made for period of curtailment early in year. (*l*) The annual report says while a yield of more than 20 lb. per ton of ore can be obtained from much of the ore, a better mining practice can be followed and more ultimate profits obtained by mining ore producing 20 lb. on the average. (*m*) Nominal. (*n*) Average for last quarter, 8633 tons. (*o*) Six months' operation.

The Utah Consolidated Mining Co. made profits in 1915 amounting to $1,128,128, and paid $600,000 in dividends.

Exploration and development at the company's property totaled 19,890 ft. Compared with 1914 copper ore reserves were more than maintained, while there has been a slight decrease in lead ore reserves. The company holds in its treasury 8250 shares of Anaconda Mining stock.

The copper ore mined and shipped during the year averaged 2.22 per cent. copper, 0.075 oz. of gold and 1.02 oz. of silver. The lead ore averaged 15.16 per cent. lead, 0.06 oz. of gold, 2.92 oz. of silver and 0.47 per cent. copper.

In addition to the ore reserves above referred to, there is between 100,000 and 150,000 tons of material of such low grade that it is not classed as ore but a large part of which can be mined at a small profit on present high price of copper.

The 1915 report of the Bingham Mines Co. shows a net income of $197,923 compared with $172,531 the previous year. Shipments were made during the year totalling 44,975 dry tons, which resulted in a production of 2,244,078 lb. of lead, 1,221,219 lb. of copper, 188,216 oz. of silver and 3399 oz. of gold. The net gain from operations was $95,465, an increase of $27,184 over the previous year. The balance of the company's income was derived from dividends paid by the Eagle & Blue Bell, which company Bingham controls through the ownership of a majority of the outstanding shares.

The entire capital stock of the Victoria Con. Mining Co. was acquired during the year. The property consists of 49 acres in the Tintic district, Utah, adjoining the Eagle & Blue Bell. The mine is opened by a 1200-ft. shaft and several tunnels, but it is believed that the ore can be extracted more economically through the Eagle & Blue Bell workings. The latter company has installed a 250-hp. electrically operated hoist which will permit the extraction of double the present output. Bingham plans an extensive development program for this year and the Yosemite mine, which suspended operations September, 1914, is to resume at once.

The annual report of the Utah Metal & Tunnel Co. for 1915 shows net profits of $329,628. During January of the present year the Bingham-New Haven produced 704,155 lb. of lead and 348,096 lb. of copper. Estimating copper at 26 cts. per lb. and lead at 6 cts. the market value would be $132,754. Deducting mining, smelting, refining and selling and charges leaves $103,824.

The Utah Metal received from the smelter for its product $61,873. Deduct mining expense, labor and supplies, and the balance would be about $45,000.

Since the annual report was drafted another new body of ore has been discovered in the Utah Metal ground, in a drift running from the 102 level. This makes five ore-bodies that have been found in the Utah

Metal and Bingham-New Haven grounds since the first one was discovered in April last in Utah Metal ground.

The production of Bingham-New Haven for 12 months and Utah Metal & Tunnel Co. for 7 months of 1915 follow:

	Gold, Oz.	Silver, Oz.	Lead, Lb.	Copper, Lb.
Bingham-New Haven	6,617	325,448	4,903,906	2,574,261
Utah Metal & Tunnel	10,297	150,446	4,956,183	299,554

An average price of $20 per oz. was received for gold, 47.177 cts. per oz. for silver, 16.505 cts. per lb. for copper and 3.957 cts. per lb. for lead.

The Eagle and Blue Bell Mining Co. produced 26,744 tons of ore having a gross value of $492,488 which was shipped to the smelters. The net smelter returns were $280,135 after deducting $212,353 for freights, smelting, sampling and assaying. The metal contents of this ore consisted of 1288 oz. gold, 441,263 oz. silver, 8,275,734 lb. of lead and 3806 lb. of copper. The net gain from mining operations, as shown by the report, was $150,392.

Copper Mining in Foreign Countries

Africa.—Estimates on the output of copper from the various mines of Africa during 1915 show a total of 27,000 metric tons, as compared with 24,135 metric tons in 1914, reported by Henry R. Merton & Co. The increase, if the estimate is correct, amounts to about 12.5 per cent. and is due largely to the increased production of the Katanga mines. A comparative table of productions of the principal copper centers of Africa covering the last 5 years is as follows:

AFRICAN COPPER PRODUCTION. (Long Tons)

	1911.	1912.	1913.	1914.	1915.
Katanga	1,100	2,345	6,790	10,700	......
Cape Colony	4,480	3,870	3,220	2,420	......
Namaqua	2,500	2,500	2,500	2,250	......
Sundries	9,000	7,655	10,000	2,820	......
Total	17,080	16,370	22,510	23,650	27,000

During 1914 there was smelted by the Union Miniere du Haut Katanga 92,381 tons of ore which resulted in the production of 10,722 tons of copper, with an average of two furnaces in operation. The production of copper during the first 6 months of 1915 amounted to 6932 tons, distributed over the several months as follows: Jan., 923; Feb., 974; Mar., 1040; Apr., 1474 (three furnaces); May, 1216; June, 1405 (three furnaces). It is estimated that the total output for 1915 will be between 14,000 and 15,000 tons. With the completion and operation of two additional furnaces with 30 to 35 per cent. greater capacity than the present ones, it is believed that the production in 1916 will be in the neighborhood of 25,000 tons per year. When the present plans of enlarging the plant have been completed the output is expected to be at the rate of 40,000 tons per year, and it is believed that this rate will be reached in 1917, and will continue from that time on.

Active mining work has, during the past 2 years, been carried on at Kambove, Luushia and the Star of the Congo mines, and on the Musoshi iron deposits for ironstone flux. The total ore and flux mined in 1914 amounted to 360,000 metric tons, which was more than double the quantity (170,000 metric tons) mined during the previous year.

The cost of ore on trucks at the mines is being gradually reduced. The costs at present average as follows:

Kambove	about 4s. 5d. ($1.07) per metric ton
Star	about 6s. 10d. ($1.66) per metric ton
Luushia	about 7s. 8d. ($1.86) per metric ton

The improvement in mining costs will continue as the exploitation progresses and the low-grade treatment schemes come into operation, and it is estimated that the high-grade ore at Kambove should not cost more than 2s. to 2s. 6d. (48 to 60 cts.) per ton and the low-grade ore about 1s. 3d. (30 cts.) per ton on trucks at the mine by the end of 1917.

The ore reserves and stocks already opened up above the present working levels at Kambove, Luushia and the Star mines, as estimated for the end of 1914, amount to a total of 6,026,500 metric tons, while the approximate flux reserve estimated for the Star and Musoshi amounts to about 900,000 metric tons. Of the ore reserves estimated above, about 20 per cent. of the total is direct-smelting ore of about 15 per cent. copper average, while the remainder is low-grade ore of about 7 per cent. average. About 25 per cent. of this remainder will, when subjected to concentration, yield concentrates of about 18 per cent. copper, which, added to the direct-smelting ore, will give 1,600,000 metric tons of 15.5 per cent. smelting ore and 4,400,000 metric tons of 6 per cent. low-grade ore, the average grade being over 8½ per cent. copper.

The work of investigating the reserves below the water levels in the Star and Luushia mines is being pushed ahead as the mining progresses. At Kambove also the investigation of the reserves in the next 100 ft. below the adit level—which is about 135 ft. above the bed of the dry Livingstone Creek—is being continued, and it was on this section of the mine that Mr. Gibb, as the result of his preliminary drilling work, estimated that there was about 3,000,000 metric tons of ore similar to that in the superficial part of the deposit.

Arrangements are being made to open up the Likasi and Chituru mines, which are close to the line of railway joining Kambove to the smelters. Mr. Adams in 1903 estimated that about 700,000 metric tons of 13 per cent. ore had been exposed in Likasi. Besides the mines already being exploited, there are, as you know, at least 150 copper deposits of importance—without including the mere copper prospects.

The gradual improvement in smelting costs and smelting conditions is very satisfactory, as shown by the following figures:

	1912	1913	1914
Furnace days worked	171	443	671
Charge per furnace day, metric tons	178	198	212
Total charge smelted, metric tons	30,280	87,800	143,670
Total output, metric tons	2,510	7,410	10,720
Average cost per ton of fuel	£9 13s. 6d.	£5 17s. 6d.	£4 9s. 6d.
Average cost per ton of flux	15s. 6d.	9s. 2d.	8s. 11d.
Average cost per metric ton of product at smelting works	£47 12s. 0d.	£30 18s. 6d.	£29 12s. 10d.

The successful carrying on of the exploitation of the Katanga copper deposits is largely dependent on the development of the scheme for low-grade ore treatment. The company has erected elaborate testing works, and extensive experiments are being carried out for the treatment of the lower-grade ores. The testing works comprise a concentration section and a leaching adjunct. The concentration section has a capacity of 150 tons per day.

Most Katanga copper ore carries a small gold (traces to 3 gm. per ton) and somewhat larger silver content (average 42 gm., maximum 72 gm., per ton) although only in rare instances does it appear to be enough to warrant separation. Buttgenbach states that the carbonate ore of the Sikasi mine carrying 22.16 per cent. copper, contains 0.781 gm. of gold and 31.136 gm. of silver or (with silver at 60 cts. per oz.) $1.04 in precious metals per ton. Among the copper ores this is one of the higher in precious-metal content. Gold and silver do not appear to increase or decrease with the varying copper content. The matte of the Star of the Congo mine, now being worked, however, carries no appreciable precious-metal values. By the erosion of the gold concentrated in the outcrops small placers are developed in streams heading in the copper deposits of Kambove, Likasi, Katanga, Musonoi, and Fungurume. At the placers named, in addition to the rough gold, the following minerals, characteristic of the copper deposits, are found: Malachite, magnetite, and hematite the latter being particularly abundant. Abundant malachite usually accompanies good values. The largest nugget found at the Kambove placer, where some of the gravel is very rich, weighed about an ounce. After present-day torrential rains fresh additions of gold are being made to several of the placers mentioned. Gold also occurs in detrital deposits on slopes below the copper outcrop.[1]

[1] *So. Afr. Min. Jour.*, Apr. 3, 1915.

The director's report of the Cape Copper Co. for the year to April 30, shows that the net profit amounts to £33,212 and £9154 is brought in. This has been apportioned as follows: £8573 has been set aside for English income tax, £2268 for Colonial income tax, and £5850 has been paid in dividends. Out of the balance dividends of 3 per cent. (making 6 per cent. for the year) on the preference shares, and 1s. per share on the ordinary shares, both less tax, has been declared payable on Jan. 1. The present accounts show an improvement as compared with those of the previous year, chiefly in consequence of a larger return of copper from the mines in Cape Colony, and increased railway receipts. The general costs of production have, however, increased, while the decline in the price of copper during the earlier part of the year adversely affected the realization of the copper in stock at the close of the previous year. The directors had hoped to be in a position to mention that the mines at Rakha Hills had reached the stage of production. The mining and concentration plant and machinery are practically completed, and the mines are in a condition to supply 300 tons of ore per day. In view, however, of the excessive rates of freight ruling, it has been found advisable to defer production until the blast furnace, which is on order, is erected, when the weight of material to be shipped will be largely decreased. The total reserves amount to 344,991 tons of 4.01 per cent. copper, 294,030 tons of this being developed ore. The reserves for the previous year were estimated at 307,747 tons of 4.13 per cent., of which quantity 99,856 tons were developed ore. The tonnage treated at the Nababeep smelting works during the year amounted to 85,109 tons, an increase of 22,523 tons over the quantity in the previous year.

The returns from the O'Okiep mine was 13,345 tons of 10.88 per cent. assay copper ore compared with 9781 tons of ore of 13.88 per cent., obtained in the previous year. The reserves of ore are estimated at 6000 tons, reckoned on a basis of 20 per cent. net assay, together with 120,000 tons of low-grade ores at surface of an estimated assay value of 4 per cent. These estimates show no change as compared with those of the previous year. The output of ore from the Nababeep South mine was 68,141 tons of 4.35 per cent. wet assay. The return of the previous year was 48,049 tons of 4.37 per cent. wet assay. The reserves of ore, excluding the capping, are estimated at 160,000 tons of 5 per cent. wet assay, being a similar tonnage and assay as at the close of the preceding year. Ore extracted from the Nababeep North mine, principally from the capping, amounted to 1657 tons of 6.55 per cent. wet assay. The Narrap mine output of ore was 2692 tons of 4.79 per cent. wet assay. Work has been suspended except at the No. 18 winze from the intermediate level below the 55-fathom level, where a vein of yellow ore is being followed.

The report of the Messina (Transvaal) Development Co., Ltd., for the year ended June 30, 1915, states that during the year 91,033 tons of ore were produced and sent to the mill and sorting plant, of which 74,564 tons were milled. The production of hand-picked ore and shipping concentrates was 12,117.41 tons, averaging 39.89 per cent. of copper, and of matte 872.03 tons, averaging 57 per cent. of copper, making a total of 12,989.44 tons, assaying 41 per cent. The ore reserves were estimated at June 30, 1915, in terms of long tons of unsorted ore—practically proved ore 131,700 tons of 6.6 per cent. copper, and prospective ore (in the developed area) 43,700 tons of 3.7 per cent. copper. This estimate is exclusive of prospective ore in depth, laterally, new discoveries on Messina leases, and on Vogelzang Farm. To the east of the Messina mine proper prospecting work on old workings to the south has disclosed promising prospects, and is producing daily a small tonnage of 7 per cent. ore. To the west at Vogelzang Farm prospecting has disclosed glance ore. Developments are also proceeding to the immediate west of the mine, where the prospects look favorable. The consignments were sold on the basis of an average price of £73 10s. for best selected per long ton of copper. The options entitling the holders to subscribe for 272,846 unissued shares of the company expired on Mar. 1, 1915. These options were not exercised and were not renewed. The company has therefore secured control of the whole of its unissued share capital. The Tzaneen-Zoekmakaar railway section was opened for traffic on Aug. 4, 1915. The completion of this section makes a direct route from the mine to Delagoa Bay of 435 miles, as against the old route, via Pretoria, of 697 miles. The company has guaranteed to the South African Government for a period of 10 years the payment of any loss that may accrue on the working of the line from the Bandolier Kop-Messina section and the Bandolier Kop-Tzaneen section, the amount payable in any year not to exceed a sum equal to 4½ per cent. on £792,000, the estimated capital cost of the line and rolling stock. It is hoped that the earnings on these sections will be sufficient to cover the maximum interest of £35,640 per year. Development work and shaft sinking were suspended in August, 1914, and re-commenced in April last. Owing to exceptionally heavy rains in January and February, 1915, the Zand River Pumping Station was washed away, and the rains interrupted railway communication with the mine for about 6 weeks, and caused a partial closing down of the plant.

The financial position of the company was greatly improved during the year, according to the annual report of the management. On June

30, 1914, the current liabilities exceeded liquid assets by about £75,000. On June 30 1915, the liquid assets exceeded the current liabilities by about £31,000, this being due to the manner in which the balance sheet had been cleared. Furthermore, at the end of 1914 the company had overdrawn at the bank about £85,000, which amount was reduced to £27,000 by June 30, 1915. Since that time the loan has been completely paid off, and a credit balance of about £49,000 established at the bank.

In the new Protectorate of South-West Africa there are said to be very great mineral possibilities, with good outlook for the production of lead, zinc, and copper. The chief copper deposits of the Protectorate are those of the Otavi district, and the principal mine is that at Tsumeb. Other occurrences of note include the Otjisongati mine, northeast of Windhuk, and the newly discovered deposits in the Kahn River Valley.

The output of copper ore by the Otavi mines for the year ended Mar. 31, 1913, was 54,100 tons. Of this total 44,500 tons were shipped, and this contained on the average of 13 per cent. of copper, 25 per cent. of lead, and 0.230 gm. of silver per ton. During the same period the Otavi Co. shipped 665 tons of copper matte containing 48 per cent. of copper, 25 of lead, and 0.440 gm. of silver per ton; as well as 400 tons of crude lead containing 98 per cent. of lead.

An increase in the rate of output took place during the 6 months ended Sept. 30, 1913, during which 25,560 tons of copper ore, 507 tons of copper matte, and 45 tons of crude lead were shipped.

Nearly the whole of this output is from the Tsumeb mine. The Otavi Valley mines contribute some 2000 tons of ore. The output at Otjisongati and other localities is comparatively insignificant.

Among the lesser known base metal occurrences of the country, yet one which is of considerable importance, is the Khan mine. The Khan copper mine is a German mining proposition with head offices at Duisberg am Rhein. The mine office in German South-West Africa is at Arandis on the Swakopmund-Ebony broad-gage railway line. From Arandis a branch line runs south to the mine in the Khan River Valley. Unlike the Otavi and Tsumeb group of properties, which are of considerable age, the Khan deposit is of recent discovery. Its organization dates from about 1910, and remarkably little appears to have been known of the venture in South Africa previous to the war. Indeed, before the South-West campaign scarcely anybody had heard of the Khan copper mine. The property embraces 10 claims of 10 hectares. The company has not the right to extract gold, or silver ores, or diamonds from the property. The connecting railway line is a private enterprise owned by the Khan Kupfergrube, Ltd. Development was actively prosecuted on the mine for 3 or 4 years, and shortly before the war broke out it was considered that the property had reached the producing stage, and it was decided to install a plant. At that time a shaft had been sunk to a depth of 500 ft., and a considerable amount of ore had been opened up. A thoroughly modern concentrator plant of a capacity of 50 tons per day was ordered from Germany, and the erection of this was carried out in a very creditable period of time. This concentrator, which had only been working for a short time previous to the war, is operated by electric power, and supplied with water from a pumping plant on the Khan River 11 miles distant. The lode here is over 6 ft. in width, and is reported to carry from 7 to 8 per cent. of copper. There may be mentioned, in conjunction with this proposition, the Henderson mine, also in the Khan Valley, and the Ida mine, near Husab. Both of these properties were reported to be opening up well previous to the war. There are two other prospective producers of copper—the Sinclair mine in the Maltahoehe district and the Okatumba near Windhoek.

Asia Minor.—In the heart of Asia Minor, near Diarbekr, and in close proximity to the Bagdad Railway are the well-known deposits of copper, heretofore exploited by the Ottoman Government, but recently offered for sale. The principal mine is the Arghana Maaden, which is equipped with its own reduction works. It has averaged about 1500 tons of copper annually for some years past, but this has probably been augmented on account of the increased demand for copper used in the manufacture of munitions of war, especially since Turkey became the ally of Germany in the great war.

Australasia.—The copper production of Australasia in 1915 is estimated to be about 35,000 tons,[1] or about 2500 tons less than the output of 1914, and more than 12,000 tons less than the 1913 production, which was the last year not affected by the war. Roughly, the drop may be ascribed to the partial cessation of operations at the Great Cobar mine, which for some years was one of the leading copper producers of the commonwealth.

New South Wales.—The output of New South Wales is usually from 9000 to 10,000 tons per annum. Owing to the partial closing down of the Cobar mine the production this year may not account for much more than 1000 tons. There are many lodes of promise, but as they are remote from railways they can not be profitably worked under present circumstances.[2]

Mouramba Copper Mines.—This company was formed in 1910 to acquire copper mines, formerly the property of the Nymagee Copper Co., Ltd., situated in the Cobar district of New South Wales. The

[1] W. P. Geary, Mining in Australasia in 1915. *Eng. Min. Jour.*, Jan. 8, 1916.
[2] *Idem.*

Nymagee Co. was floated in this country in 1906, but the operations were suspended the year following. The report now issued covers the year ended June 30 last and shows that the company was marking time owing to adverse metal conditions. Since the period covered by the report smelting has been re-commenced, and matte containing 633 tons of copper has been produced from 19,255 tons of ore, being an extraction of 3.28 per cent. A second blast furnace is to be blown in shortly. E. J. Rodda has recently been appointed manager, and he reports that developments are giving encouraging results.[1]

Queensland.—Queensland has been more fortunate in respect to its railway facilities to mining centers, and as a result has rapidly progressed in copper production. Queensland produces more than 50 per cent. of the total output of the commonwealth and for 1915 turned out approximately 19,000 tons of copper. This was drawn chiefly from the Cloncurry district, which includes such mines as Hampdem, Mount Elliot and Mount Cuthbert. The Mount Morgan mine is now generally known as a copper producer, after having in the past contributed several million pounds' worth of gold.

The electrolytic refining and smelting works at Port Kembla has been kept in constant operation in spite of the isolation from its market in Germany as a result of the war. Satisfactory arrangements were effected with English firms for the disposal of the products of the plant so that no apparent loss of time was experienced. Electrolytic copper is being produced at the present time at the rate of about 2000 tons per month, and the bulk of this is shipped to London as soon as it is recovered. The chief sources of supply are Mount Morgan (Queens.) 800 tons monthly, Mount Lyell (Tas.) 600 tons, and various small mines of the Commonwealth.

At the junction of the Einasleigh and Copperfield Rivers in N. Queensland is the Einasleigh copper mine which has recently been brought to be a considerable producer. The output from this mine practically keeps the Chillagoe smelters supplied with the needed ore to maintain their furnaces in operation. The ownership of the mine was acquired by the Chillagoe Co. in 1911, and the total production for that year was brought up to 15,793 tons. In the following year the output of ore amounted to 24,418 tons, and in the first 10 months of 1913 it produced 22,480 tons.

The ore is of a pyritic character, being a mixture of pyrrhotite and chalcopyrite with a siliceous gangue, carrying an average of 6.17 per cent. copper as determined by the monthly yields of the Chillagoe smelter during the years from 1909 to 1913. Small amounts of gold and silver

[1] *Min. Mag.*, Feb., 1916.

together with a little over 1 per cent. zinc are constantly found in the ore.

A conservative estimate of ore reserves made at the end of April, 1913, gave a total of 11,000 tons of ore insight above No. 4 level; 19,000 tons of probable ore between the levels 4 and 5. The average copper-content of all of this ore is between 5 and 6 per cent.[1]

Smelting was in progress at the Corella Copper Co.'s property, for a little less than half of the 6 months ended Oct. 31 last, a stoppage being necessitated, owing to a shortage of water. A supply, estimated to be sufficient for 12 months, has been secured through a good rainfall, and the furnace has been re-started. Prior to the stoppage, 4723 tons were treated for the half-year for 630 tons of matte, yielding 287.8 tons of blister copper, containing 279.6 tons of fine copper and 166½ oz. of gold. During the period of idleness the capacity of the furnace was increased by 20 per cent., and a larger production of matte can be looked for in future. Receipts on working account were £23,463, and the balance carried to profit and loss was £4923, while the net profit was £3600 as the result of about 12 weeks' smelting. The first dividend of 1s. was paid during the term, and absorbed £5000. Ore reserves are estimated by the manager (Mr. W. W. Horsburgh) at 38,000 tons, containing 1990 tons of copper, of which 24,500 tons, containing 1540 tons of copper, exist in the Rosebud mine. Results from development work at the 300-ft. level of the latter property are taken to indicate the existence of a large tonnage of siliceous sulphide ore. The drive south was extended to 28 ft., marked improvement being recorded for the last 8 ft. While the average value was 9.6 per cent. copper, the face was slightly higher, and the average width along the drive was 60 in., without the eastern or western wall showing.[2]

South Australia.—The production of South Australia is estimated at 6500 tons of copper, being almost entirely the output of the Wallaroo & Moonta property. These old established mines are still prosperous, although in many respects operations are conducted on exceedingly conservative lines.

According to the report of the general manager of the Wallaroo and Moonta Mining and Smelting Co., for the year ended Dec. 31, 1915, that company's affairs have been carried on satisfactorily during the past year. The higher prices paid for copper have enabled the management to work somewhat leaner ores than heretofore mined, and the improved methods of handling low-grade material have reduced the costs in some respects, offsetting the increased expense due to the scarcity of men and supplies.

[1] Queensland Geol. Surv. *Publication* No. 246, Brisbane, 1914.
[2] *Queensl. Govt. Min. Jour.*, Feb. 15, 1916, p. 52.

The Wallaroo mines produced 58,551 tons of ore containing 5608 tons of fine copper, or 9.58 per cent., and the Moonta mines had an output of 7994 tons of ore from which 1344 tons of copper was extracted, corresponding to 16.82 per cent. copper-content. The cementation plant of this company produced 938 tons of precipitate containing 686 tons of copper, or 73.07 per cent. The Wallaroo smelting works treated a total of 67,407 tons of ore and precipitate from which were extracted 7653 tons of refined copper, 3027 oz. gold, and 2884 oz. of silver. The manufacture of bluestone has been discontinued, but 5966 tons of sulphuric acid was produced at a cost of 20s. 7¾d. per ton.

At the request of the Federal Government the directors have undertaken the refining of certain copper materials from the Queensland mines by the purchase of their matte and blister copper, which will increase the output of the Wallaroo brand of copper considerably for the current year. A contract has been entered into with the Munitions Department of the British Government for the purchase of the balance of the company's output for 1916 over and above certain other contracts with British munition makers, and the Indian Mints, at a fixed price of £100 per ton.

The government of South Australia has recently appointed Mr. J. D. Connor to the position of Government Metallurgist with the purpose of developing methods of treatment suitable for the low-grade copper ores of the Commonwealth. Mr. Connor will visit America for the purpose of gathering data on the most modern hydro-metallurgical plants in operation there, and upon his return to South Australia he will erect a small experimental mill in which to test the ores of the State.

In providing means whereby individual mineowners or companies may obtain authoritative reports on the feasibility of treating their copper ore by leaching processes, the Minister feels that the Department of Mines will be offering the most valuable form of assistance to the industry. Should the experimental work be successful it is hoped that some of the copper mines which are now lying idle, or being worked on a restricted scale, will become important contributors to the annual output of copper.[1]

Western Australia.—The Western Australian production is small and may be set down at 950 tons, the bulk of which came from the mines and smeltery which are being worked by the State Government at Ravensthorpe. Papua holds a number of exceedingly promising copper propositions. One in particular, the Laloki, has been subject to extensive development, and the ore reserves are set down at some hundreds of

[1] *Queensl. Govt. Min. Jour.*, Nov. 15, 1915, p. 545.

PRODUCTION OF COPPER IN AUSTRALASIA
(In tons of 2240 lb.)

Year.	New South Wales. Ingots, Matte and Regulus. Tons.	New South Wales. Ingots, Matte and Regulus. Value.	New South Wales. Ore. Tons.	New South Wales. Ore. Value.	Queensland. Copper, Tons.	Queensland. Value.	South Australia. Copper, Tons. (a)	South Australia. Value.	Tasmania. Blister Copper. Tons.	Tasmania. Blister Copper. Value.	Tasmania. Copper Ore. Tons.	Tasmania. Copper Ore. Value.	Western Australia. Copper Ore, Tons.	Western Australia. Copper Tons. (b)	Western Australia. Combined Value.
1908	8,679	£496,564	392	£6,248	14,961	£893,535	5,628	£338,000	8,833	£603,063	1,185	£6,588	2,503	479	£57,091
1909	6,857	423,642	109	1,095	14,494	853,196	5,697	334,584	8,638	586,419	1,588	21,619	6,959	833	104,644
1910	8,435	450,491	4,455	35,766	16,387	932,489	5,102	306,120	8,193	553,822	671	13,150	6,309	1,281	95,928
1911	10,618	578,198	1,482	11,904	20,384	1,151,351	5,922	332,5 00	6,022	385,797	2,286	22,852	9,825	829	78,364
1912	8,990	560,025	2,044	19,766	23,120	1,698,280	6,295	461,500	5,136	430,965	1,392	9,479	13,607	1,703	120,158
1913	9,153	595,826	308	2,907	23,655	1,660,178	7,161	488,986	4,569	364,332	1,967	10,932	(c)4,339	(c) 82	145,513
1914	3,500	274,671	......	....	18,436	1,118,648	6,881	417,487	7,509	477,361	3,288	18,680	(c)3,913	(c)183	38,174
1915	....	....	......	....	19,704	1,428,793	7,725	561,247	7,901	709,167	66	367	737	946	91,169

(a) Small amounts of copper ore and sulphate not included here. (b) Ingots and matte. (c) Exports.

thousands of tons of 4 per cent. pyritic ore. Railway facilities, however, are essential before the mine can be worked on a commercial scale.

Tasmania.—The Tasmanian output approximated 7350 tons, of which 7000 tons was credited to Mount Lyell. This company has lately been able to reduce its cost somewhat by the installation of water power, and in addition has been fortunate in the lower level sin opening up a large quantity of high-grade ore.

The Mount Lyell company is a factor in the superphosphate industry. The pyritic ores from the Mount Lyell and Chester mines furnish considerable of the sulphur necessary for acid making. Extracts from the report of the company for the 6 months ended Sept. 30, 1915, show that 175,195 tons of ore were mined, 176,465 tons were treated, and an average of 2.93 blast furnaces were kept in blast. The hydro-electric plant was in continuous operation and gave perfect satisfaction. Surveys have been made with a view of enlarging the plant, and construction work is in progress on a flotation plant, and also on a new reservoir which will have a capacity of 54,000,000 gal.[1]

Bolivia. (By J. T. Singewald, Jr., and B. L. Miller).—The estimated production of copper in Bolivia during 1915 is about 3000 tons[2] which is slightly in advance of the 1914 output of 2743 metric tons. The value of the copper output of Bolivia now

[1] *Comm. Rept.*, Jan. 25, 1916, p. 349.
[2] *Eng. Min. Jour.*, Jan. 8, 1916, p. 49.

ranks second to that of tin due to the increase in production from the Corocoro district since the opening of the Arica-La Paz Railroad. During 1914, there were exported from Bolivia 3874 metric tons of copper concentrates carrying 80 per cent. to 90 per cent. copper and 4793 tons of ore rated at 40 per cent. to 50 per cent. copper. In addition to the Corocoro production, there is a small copper output from the mines of the Compania Huanchaca de Bolivia at Pulacayo; from those of the Aramayo Francke Mines, Ltd., to the south of Pulacayo; about 50 tons of cement copper carrying 60 per cent. to 70 per cent. copper resulting from the lixiviation of the Potosi silver ores, and a small amount from the Oruro silver ores.

The Corocoro district is located near the western edge of the Bolivian plateau at an elevation of 13,000 ft., 340 km. by rail from Africa. It is connected with the main line from Arica to La Paz by a 6-km. branch from Tarejra. Before the completion of this line, less than 3 years ago, the products of the district had to go out by way of the Desaguadero River to Lake Titicaca and thence by rail via Arequipa to Mollendo. The advent of the railroad consequently made a great reduction in transportation costs and hence brought on a new era in the development of the district. With the exception of a few very small mines, the operations are entirely in the hands of the Corocoro United Copper Mines, Ltd., of London and Paris, and the Compania Corocoro de Bolivia of Santiago, Chile. Rumors were persistent in Bolivia throughout the year that the holdings of these two companies were to be acquired by American interests, and at the close of the year it was definitely announced that the Anaconda Copper Mining Co. had the mines under option and their engineers were in Bolivia making an examination of the properties. The advent of this company into Bolivia will mark the first large investment of American capital in a Bolivian mining enterprise and place Corocoro in the front rank among copper-producing districts.

Corocoro shares the distinction with the Lake Superior region of the United States of being the two important copper districts in which native copper is the chief form of occurrence of the metal. Until Corocoro had railroad connections this was the only type of ore worked, but since then the sulphides have furnished an important part of the output of the district. The sulphide ores are hand-sorted to run 20 per cent. copper and are exported to the United States and Europe. The reject is being stored for future treatment by flotation. These ores consist of chalcocite which at the surface has undergone alteration to the green basic sulphate, malachite, and azurite. A curious feature of the mineralization is that the sulphides are found near the surface and in depth give way to the native copper ores. Both types represent impregnations along the arenaceous beds of a series of red shales and sandstones.

During 1915, the Corocoro United Copper Mines, Ltd., was producing about 300 tons of native copper ore daily, averaging 2½ per cent. to 3 per cent., and the Compania Corocoro de Bolivia about 200 tons daily averaging 4½ per cent. copper. The output of sulphide ores was greatly interfered with on account of a scarcity of cars on the railroad. The Corocoro United Copper Mines, Ltd., was shipping about 30 cars of 22 per cent. ore monthly, and the other company which had several thousand tons in readiness for shipment had stopped mining them temporarily while waiting for the car shortage to be relieved. According to the *West Coast Leader* for Mar. 2, 1916, the production of the entire country for 1915 was 17,872 metric tons of copper, valued at $3,820,821.

Canada.[1]—The copper production of Canada in 1915 was the highest ever recorded. The output of the smelters together with the estimated recoveries or amounts paid for in ores exported amounted to 102,612,486 lb., as compared with 75,738,386 lb. in 1914, which corresponds to an increase of 35 per cent. The value of the output of these 2 years at the average New York value of refined copper is $17,726,307 and $10,301,606, respectively, the increase being 72 per cent. The highest previous yearly production was made in 1912, when an output of 77,832,127 lb. was reached.

Of the total production in 1915, 42,050,347 lb. was contained in blister copper, 44,230,052 lb. in copper and copper-nickel matte, and 16,332,087 lb. was contained in ores exported. The production by districts was as follows:

CANADIAN COPPER PRODUCTION (*a*)
(In pounds)

	1911.	1912.	1913.	1914.	(*c*) 1915.
Quebec	2,436,190	3,282,210	3,455,887	4,201,497	6,082,003
Ontario	17,932,263	22,250,601	25,884,836	28,948,211	39,303,279
British Columbia	35,279,558	50,526,656	45,791,579	41,221,628	56,692,988
Yukon	....	1,772,660	1,843,530	1,367,050	534,216
Total	55,648,011	77,832,127	76,975,832	75,738,386	102,612,486

(*a*) Min. Prod. of Canada. (*c*) Min. Prod. Can., Prelim. Rep. for 1915, Ottawa, 1916.

Quebec.—The production in Quebec from pyritic ores was 6,082,003 lb. as against 4,201,497 lb. in 1914.

In the Eastern Townships of Quebec[2] the Weedon copper mine is one of the principal producers of pyrite ore. During the last 5 years this mine has produced 174,000 tons of ore having an average copper-content of 3.62 per cent., and carrying values in zinc, silver and gold, besides its sulphur-content of 40.74 per cent. The ore sells for about

[1] Statistics taken from Preliminary Report of Mineral Production of Canada for 1915, Ottawa, 1916.
[2] *Can. Min. Jour.*, Jan. 15, 1916, p. 46.

$9 per ton, payment being made on the basis of sulphur-an d copper-content. The main ore-body of the Weedon mine is a lenticular mass of cupriferous pyrite with which very small amounts of galena and zinc blende are associated; it has proved to be 570 ft. in length with a maximum thickness of 40 to 45 ft., and striking N. 37° E., dips 40° to 45° to the southeast. On the average the northeastern portion of the lens has been found to carry somewhat higher values in copper than the southwestern. Three shafts have been successively sunk on the vein to depths of 96, 350, and 470 ft. At first, the ore was taken by teams from the mine to the railway, a distance of 5 miles, at a cost of about 80 cts. per ton. In 1912, a Bleichert aerial tramway, 19,500 ft. in length, was constructed from the mine to the railway, at a cost of $1.75 per ft., and the cost of transporting the ore to the railroad thus has been reduced to 6.7 cts. per ton.

At present, the Eustis mine is working at a depth of about 3900 ft. on an average incline of 38°. In 1912, at a depth of 3450 ft. the ore-bodies comprised four parallel lenticular veins known as the foot wall, the main, the shaft and No. 1 veins. The foot wall and shaft veins then carried somewhat better values in copper than the others; but in 1913, the average product of the mine contained slightly less than 2 per cent. of copper. At present, work is progressing at the bottom of the mine, upon two lenticular bodies of ore that average 2 per cent. in copper. The maximum capacity of the mine equipment is about 200 tons per shift. The concentrating mill, which had a capacity of from about 10 to 12 tons of mill feed per hour, and in which an Elmore oil concentrator was installed in 1913, was burned in August, 1915. A new mill is in course of construction.

Ontario.—The production in 1915 is reported as 39,303,279 lb. as against 28,948,211 lb. in 1914 an increase of 10,355,068 lb. or 35.7 per cent.

The Ontario production is derived chiefly from the nickel-copper ores of the Sudbury district and of the Alexo mine, although there is a small amount of copper contained in the silver ores shipped from Cobalt, some of which is paid for. There was also a small shipment from the old Massey mine which was re-opened during the year.

For the first time in its history, a copper shipment was made from Cobalt. This consisted of a car load of chalcopyrite ore from the Brewer and Price claim on the Montreal River, near Latchford. It was shipped by the Rand Syndicate to the States. The same syndicate is now working a copper prospect near the Sterling mine, a few miles west of mile post 76 on the T. & N. O. Railway.

British Columbia.—British Columbia also shows a largely increased production in 1915, the total being 56,692,988 lb. as against 41,219,202 lb. in 1914 an increase of 15,473,786 lb. or 37.5 per cent. The 1915 production in this province included 47,064,234 lb. recovered in blister and matte, etc., and 9,628,754 recovered from ores shipped to smelters outside of Canada.

The chief factor in this improved situation was the Granby Consolidated Co., which produced 21,801,000 lb. from its Hidden Creek mine, Observatory Inlet, as compared with 12,128,000 lb. in 1914. Then there was 2,175,000 lb. from the Rocher Déboulé mine, near Hazelton, a property that only several months ago commenced to ship ore that was smelted at the Granby company's works at Anyox, Observatory Inlet. The production of the Britannia mine, in the Vancouver division, was about 10,000,000 lb., which was 2,000,000 lb. less than that of 1914. This decreased production was the direct result of the destruction early in 1915 of the upper terminal of the aërial tramway and other headworks at the Britannia mine by a big snow and land slide. Adding the output of the Marble Bay mine, on Texada Island, to the foregoing figures brings the Coast district (including Skeena and Omineca) total up to approximately 34,000,000 lb., as compared with 22,712,480 lb. for the interior districts of Boundary and Kootenay, which previous to 1914 produced much more copper than did the Coast district. Approximate figures for interior districts are: Boundary and Yale 17,874,000 lb. and Kootenay 4,817,000 lb. The chief producer in the Boundary district was the Granby Con., which shipped from its mines in Phœnix camp ore that yielded 16,046,000 lb. of copper, while the British Columbia Copper Co. produced 1,505,000 lb., and the Iron Mask mine at Kamloops shipped ore to Trail from which it is estimated 350,000 lb. was recovered. Of Rossland mines, Le Roi is thought to have produced 2,800,000 lb., the Center Star group, 1,086,000 lb., and the Josie group, 895,000 lb.

The copper smelter of the Granby Consolidated Mining, Smelting & Power Co. (Ltd.), at Anyox, British Columbia, is producing blister copper much more cheaply than the smelter belonging to the same company at Grand Forks, British Columbia. The report of the company for the quarter ended Sept. 30, 1915, shows the cost at Anyox as 7.939 cts. per lb., while the cost at Grand Forks for the same period was 10.91 cts. per lb. Adding to these figures the cost of freight, refining, selling, and general eastern expense, brought the Anyox figure up to 9.4 cts. per lb. and the Grand Forks figure up to 12.4 cts. per lb.

These figures, however, are the net cost of the copper after deducting the precious-metal credits, which amount to some 3.2 cts. per lb. of smelted product.

It is expected that further reductions will be shown in the cost of production at Anyox, as the fourth furnace and the new agglomerator just installed have been charged to expense of operation. Furthermore, the agglomerator is expected to give an increased recovery of about 4 lb. of copper per ton of ore.[1]

British Columbia claims the largest copper mine in the British Empire, the Britannia mine on Howe Sound 25 miles north of Vancouver. The plant when finished will treat 4000 tons of ore per day. The ore contains 3 per cent. copper and a little silver; it is estimated to be worth $8 to $10 per ton. Development by adits, shafts, and levels indicates several million tons of ore at Britannia Mountain, 3.8 miles from the beach and outcropping at an altitude of 3500 ft. An aërial tramway 13,000 ft. long and of 1000 tons daily capacity is carrying the ore to the mill; incidentally, the force of gravity of the descending buckets is utilized to operate an air-compressor at the mine, and the tramway has also been used to transport machinery and supplies. This tramway will continue in operation after the electric railway system is completed. A 30° inclined railway a mile long now under construction (at a cost of $140,000 per mile) will deliver ore to the mill. In addition there will be an electric railway 3½ miles long of 3 per cent. grade.[2]

The Canada Copper Corporation, Greenwood, B. C., was organized in March, 1914, with an authorized capitalization of $5,000,000. At the smeltery 299,928 tons were handled consisting of 193,512 tons of British Columbia Copper Co.'s ore and 106,416 tons of custom ore. There were 5129 tons of converter slag made and smelted which contained 1627 tons of custom ore and 466 tons of clay. There were 41,026 tons of coke used, which was equal to 13.52 per cent. of the entire charge fed to the furnaces. The average grade of the matte was 39.7 per cent. copper. The blast-furnace slag contained 0.251 per cent. Cu, 0.0039 oz. Au, and 0.07 oz. Ag per ton. The average analysis was 41.9 per cent. silica, 18 per cent. iron and 22 per cent. lime. The production of fine copper was 4,116,190 lb; gold, 14,442 oz., and silver, 63,501 oz. The company closed the year with $181,106 in cash on hand.

At the Motherlode mine the cost of placing the ore on board the railroad cars at the mine was 85.48 cts. per ton. This cost includes ore sorting at 4.55 cts. per ton; development, at 8.7 cts. per ton, or $5.97 per ft. of work; and diamond drilling at 6.48 cts. per ton of ore or $2.38 per ft. drilled.[3]

Yukon.—The Yukon production is reported as 534,216 lb. in 1915 as compared with 1,367,050 lb. in 1914.

Newfoundland.—Copper appears to have been the first of the mineral products of the island mined, the Tilt Cove mine, in Notre Dame Bay,

[1] *Comm. Rept.*, Jan. 12, 1916, p. 153.
[2] *Min. Electr.* and *Eng. Record*, Aug., 1915.
[3] *Can. Min. Jour.*, Aug. 7, 1915, p. 232.

having been operated more or less since 1864. This particular mine is reported to be nearly exhausted, but it is said that new lodes have been found at five other points in Notre Dame Bay. Other copper mines have been more or less worked at York Harbor, Bay of Islands, at Goose Cove in Hare Bay, and at Quidi Vidi, near St. Johns. The aggregate product of these mines from Jan. 1, 1871, to Jan. 1, 1916, is estimated at 1,650,000 tons of ore, of which about one-third was exported to the United States.[1]

Imports and Exports.—Exports of copper according to Customs records were; copper fine in ore, etc., and copper in pigs 102,729,579 lb. valued at $12,460,356, there were also exports of old and scrap copper amounting to 4,161,600 lb. valued at $616,553.

The total value of the imports of copper in 1915 are recorded as $3,467,586 as against $4,256,901 in 1914. The imports in 1915 included 16,818,116 lb. of copper in pigs, ingots and manufactures, valued at $3,104,382; other manufactures valued at $263,922, and copper sulphate 1,854,850 lb., valued at $99,282.

The imports in 1914 included 26,280,815 lb. crude and manufactured copper valued at $3,983,322, copper sulphate 1,143,039 lb. valued at $53,802 and other manufactures of copper valued at $219,777.

Chile (By B. L. Miller and J. T. Singewald, Jr.).—During 1915 Chile showed a further increase in the production of copper over its previous yearly records, the output being 47,142 metric tons,[2] as compared with 40,876 tons in 1914, and 39,434 tons in 1913.

The year 1915 was very favorable for the copper industry in Chile. In May the first unit of the extensive plant of the Chile Exploration Co. at Chuquicamata was completed and, in addition, the high price of copper stimulated the more active mining of copper ore in various places throughout the country with the result that many mines and smelters long idle were put in operation.

Probably no other country of the world contains as many copper mines as Chile and a traveler in that country readily sees why for many years it held the world's supremacy in copper production. A gentleman, well informed with the situation, is authority for the statement that there are probably 2000 mines that are regularly or intermittently worked. Most of these are small mines located some considerable distance from the railroad and consequently only the high-grade hand-picked ores are utilized. These are carried to the nearest railroad stations on the backs of mules and thence shipped to customs smelters and during 1915 it was a common sight to see a dozen or more small piles of copper ore on the platforms of some of the stations of the longitudinal

[1] *Comm. Rept.*, Mar. 9, 1916, p. 950.
[2] *Eng. Min. Jour.*, Jan. 8, 1916, p. 49.

railroad between Coquimbo and Santiago, each belonging to the owner of some small mine.

Chile is rapidly changing the character of its copper industry just as has happened in the United States and soon the output from the low-grade ores will so greatly overshadow that of the high-grade ores as to make the latter seem insignificant. It is also of interest to note that through the possession of the extensive low-grade copper deposits the control of the Chilean copper industry is rapidly passing into the hands of North American capitalists, a state of affairs that in some quarters is viewed with disfavor and has revived the discussion of the advisability of placing an export tax on copper, similar to that which the Government now levies upon nitrate and iodine. In the past, the native mine operators have apparently lacked the confidence necessary for the expenditure of large sums of money in equipment hence it is probable that without the influx of North American capital Chile's copper production would have continued to decrease steadily, while the present outlook is most encouraging and justifies the belief that Chile will shortly regain and long held second place among the copper-producing countries of the world.

The Chile Exploration Co. after 3 years of drilling and erection of plant started production on a commercial scale on May 19, 1915. The plant as now operated has a daily capacity of 10,000 tons but up to the close of the year had not quite reached its maximum. The intention of the company is eventually to build three other units of equal capacity making a total of 40,000 tons of ore treated daily.

Notwithstanding the large amount of ore previously determined, drilling was continued throughout the year and the ore-body now developed contains approximately 400,000,000 tons, making it the largest known copper deposit. The deepest boring reached the depth of 1685 ft. and it is believed that in other portions of the deposit workable ore will be found at equally great depths. Of the reserves thus far developed over one-half consists of oxidized ore containing mainly brochantite, atacamite, and chalcanthite, averaging according to assays about 1.9 per cent. copper; mixed ore containing oxidized and sulphide minerals constitutes about one-fourth and assays about 2.9 per cent. copper; while the remainder consisting of sulphide ores containing chalcocite, covellite, and chalcopyrite averages about 2.5 per cent. copper. The average for the entire ore-body is over 2 per cent. copper.

At present only the oxidized ores are being worked in a single bench that at the extreme height will have a working face 180 ft. in height. In this first slice the percentage of chlorine is higher than the average ore and necessitated some slight changes in the plant, particularly in the enlargement of that portion where the cupric chloride solution is converted into insoluble cuprous chloride by passing through revolving drums containing shot copper. Otherwise the plant as first constructed underwent few changes, a remarkable circumstance in view of the fact that the leaching and electrolytic methods used embody a number of new ideas. Although as yet not demonstrated, it is claimed that the company can soon put copper in the chief market centers of the world at an approximate cost of 6 cts. per lb.

Several copper mines adjoining the property of the Chile Exploration Co. belonging to the Compania Minera de Calama and to Gibbs and Co. were also operated during the year. The ore is mixed sulphide and oxidized minerals consisting primarily of brochantite, chalcocite, enargite, and chalcopyrite. The ore in these mines is in the form of ore-shoots or veins and less disseminated than in the deposits of the Chile Exploration Co. Most of the ore is shipped to a smelter at Calama.

During the year the Braden Copper Co. was active in making many improvements in the plant. The ore reserves were somewhat extended by development work and now aggregate about 90,000,000 tons. The mill capacity was increased to 4000 tons a day while plans were made for a much greater increase. Many changes were made in the mill especially in the flotation department while the smelter also was improved in many ways. Toward the close of the year the smelter was daily treating 350 tons of concentrates derived from 4000 tons of ore and producing 60 tons of blister copper. The snow slides which in the past have caused much disaster were less severe during the winter of 1915 and the loss due to them was inconsiderable. The employees of the company during the year started a monthly publication called "Teniente Topics" which keeps the public informed in regard to the active development of the company.

The most important new developments of the year in Chile were the continued development of the Potrerillos copper property which has been acquired by the Anaconda Copper Mining Co. This deposit was first prospected by William Braden who sold it to the Anaconda Co. About 75,000,000 tons of ore containing 1.8 per cent. copper have thus far been developed with prospects for a much greater tonnage. The plans for the development call for the construction of an 80-mile railway besides an elaborate concentrating mill in which flotation will probably be employed. It will be several years before the plant begins production.

China (By T. T. Read).—The copper production of China is considerable in amount but there is no way of ascertaining any figures as the metal goes directly into domestic consumption. The largest mines are at Yunnan, though there are others in Kwei-chou and Sze-chuan.

The mines at Tung-chuan, in Yunnan, have been worked since 1700 and have an estimated total production of 70,000,000 lb. of copper. They have recently been taken over by the Ministry of Finance and the output will be used in the making of copper coins. Mr. V. K. Ting, Director of the Geological Survey of China, described these mines in the *Far Eastern Review* of November, 1915. Concerning the copper mines of Kwei-chou no recent reports are available. Important copper deposits are said to exist in Hunan, but these are not being worked.

Cuba.—The copper production of Cuba comes mainly from the El Cobre mines, near Santiago. The Cobre mine has finally been unwatered and the old workings that have been flooded for the past 80 years go to a depth of 1120 ft. In the upper workings the ore is largely oxidized, but in depth the sulphides, mainly pyrite and chalcopyrite, are found with a zone of mixed oxides and sulphides occupying an intermediate position.

The Cuba Copper Co., operating the Cobre mine, was among the first to experiment with flotation, using the methods introduced by the Minerals Separation Co. A little over 2 years ago an experimental plant with a capacity of 50 tons was erected, and as a result of the experience gained, a 600-ton plant was put into operation and has been running since March, 1914.

The ore is crushed dry by rolls, screened through 8-mesh and conveyed to the storage-bin. Four Hardinge and two ordinary tube mills are fed from the storage-bin by individual Challenge feeders to insure equal distribution of feed. Each is fitted with an electric alarm to give warning the moment anything goes wrong. It is interesting to note that one man's life has been saved by these signals. The man fell into the storage-bin and blocked a feeder. He was taken out and resuscitated with great difficulty. Failure of instant notification would have cost his life. However, the main object is to insure regular feed, as the ratio of oil to ore is most important. Cresylic acid, carbolic acid, Mexican crude, and light asphalt oil are fed into the tube mills by special machines. Grinding is done on a thick pulp, 25 to 30 per cent. moisture, until 65 per cent. will pass 60-mesh. The pulp goes to the M. S. box without classification or re-grinding. Fourteen stirrers with 13 spitz boxes are used. Direct concentrate is taken from as many boxes as show a good concentrate, the poorer froth being returned to the first box. Number of boxes treated varies with this and is changed by the operator who judges by eye. All the coarse tailing is roughed over Wilfleys to recover the coarse pyrite carrying copper. Caustic soda and fuel oil are added as needed in the stirring-boxes. The various concentrates go to the classifier, the coarser product passing direct to the bins with about 8 per cent. moisture. The overflow is thickened and drained by an Oliver filter, giving about 20 per cent. moisture. The plant gives about 85 per cent. extraction of the insoluble copper in a 3 per cent. feed. It is interesting to note that with El Cobre ores using a cold neutral solution wood-products have not given any satisfaction. The concentrate carries 16 per cent. copper, 35 per cent. iron, 40 per cent. sulphur, and 9 per cent. silica.

Germany.—On account of the war there are no official statistics on the copper production of Germany during the past year. Numerous articles in the current periodicals have lately appeared with various arguments as to the copper situation, but in all of them there is much evidence of uncertainty. Before the war Germany produced from the mines at Mansfeld, Eislaben, and Hettstadt, but principally from the first-named place, about 25,000 metric tons of copper annually. It is to be expected that there has been a notable increase in the output of these mines since hostilities began on account of the practical impossibility of getting American copper into Germany as a result of the British blockade, and it is variously estimated that the maximum output of the German mines ranges from 40,000 to 50,000 tons of copper under present vigorous mining.

It seems to be well established that any attempt to create a copper famine in Germany by stopping its importation will fail because of the large stock of raw materials on hand when the war began.

According to an American bulletin published in Berlin the German authorities estimate that there are available in Germany 2,000,000 metric tons of copper in one form or another, which quantity will meet the military requirements for upward of 10 years. Shall we then estimate the German use of copper in warfare at 200,000 tons per annum and that of the Allies at as much more, or a total of 400,000 tons—40 per cent. of the world's production? Probably no printed statement of this kind would be allowed in Germany if it were not correct, for certainly there would be no object in exaggerating the rate of consumption, although there might be with respect to the supply.

As to the latter, the reports do not read so comfortably as the bald statement of the huge quantity that is available. A registry of all the copper in the Empire has been made, and nobody is permitted to sell any copper article without permission of the authorities. For copper goods that were voluntarily deposited before Sept. 25 a price of 43.3 cts. per lb. is being paid. That figure, together with news coming privately, indicates that copper in Germany is becoming very scarce.[1]

A new German electrolytic copper-refining plant is to be installed,

[1] *Eng. Min. Jour.*, Sept. 11, 1915, p. 449.

according to the London *Electric Review.* It is announced that the Hüttenwerke Niederschonweide proposes to erect a plant in the vicinity of Bitterfeld for the production of electrolytic copper. The energy required is estimated at 2,000,000 kw.-hr. per annum, which would be obtained from the Electro Works Co., of Golpa Jessenitz. The carrying out of the scheme would increase to three the number of works turning out electrolytic copper, the two existing being those of the North German Refinery Co. and the Kayser Metal Co.

Great Britain.—The total imports of copper ore into the United Kingdom for 1915 were 38,131 tons, compared with 71,573 tons for 1914 and 94,265 tons for 1913. Chile supplied 13,012 tons of the imports, against 25,327 tons for 1914 and 39,028 tons for 1913.

The price of electrolytic copper increased during 1915 from £61 to £108 ($296 to $525). In standard metal the rise was less pronounced, the top prices being £86 5s., a gain of £28 17s. 6d. At the close of the year the margin between raw and refined copper was £23. The normal margin is only £3 or £4.

The total supplies of copper in Europe during 1915 were 400,855 tons, against 485,215 tons in 1914 and 537,300 tons in 1913. European deliveries were, respectively, 411,253, 479,303, and 551,021 tons. These last figures should not be taken as an exact indication of decrease in European consumption as they do not take account of brass and brass goods.

There were 25,577 tons of raw and manufactured copper exported from the United Kingdom during 1915, against 40,092 tons for 1914 and 53,208 tons for 1913.[1]

Japan.—The copper production of Japan, according to the Imperial Japanese Mining Bureau,[2] during 1914 amounted to 69,816 metric tons valued at 38,350,311 yen,[3] and during the following year it is estimated to have been approximately 75,000 metric tons, or about 7½ per cent greater than the preceding year. This is due to the great demand for copper in the trades as a war material. There are about 40 large copper mines in Japan, but the four largest ones produce more than half the total tonnage. The output of the principal mines is shown in the following table:

The Ashio Copper Mines, of Japan, formally opened on Sept. 27, 1915, its new dust-settling system at the Honzan smelting works, near Ashio, in Tochigi Ken, on the island of Hondo. The Ashio company has in this district a concession of about 4000 acres. The three principal mines are Honzan, Kotaki and Tsudo, which are situated about 3 miles apart.

[1] Supplement to *Comm. Rept.*, Mar. 28, 1916.
[2] Mining in Japan, *Eng. Min. Jour.*, Jan. 15, 1916.
[3] The yen is almost equivalent to 50 cts.

Each has its own ore-dressing plant, but the smelting for all the Ashio mines is done at Honzan. The blister copper is refined at the Nikko Copper Works, about 20 miles northeast of Ashio.

COPPER PRODUCTION OF PRINCIPAL JAPANESE MINES
(In tons of 2000 lb.)

	1911.	1912.	1913.	1914.	1915.
Ashio	8,483	10,530	9,335	10,631	11,000
Kosaka	6,606	8,867	6,660	7,520	8,000
Hidachi	6,243	8,704	9,835	10,132	12,000
Besshi	7,573	8,537	7,523	7,446	7,500
Ozaruzawa	2,172	2,385	2,062	2,087	(*b*)
Ikuno	1,654	1,884	1,801	1,998	(*b*)
Furokura	2,014	1,719	....	....	....
Ogoya	1,246	1,540	1,441	1,482	(*b*)
Arukawa	1,410	1,413	1,056	919	....
Kamaishi	....	....	1,152	1,167	....
Ani	....	....	1,137	1,373	....
Other mines	20,252	23,299	9,749	10,691	36,500
Total	57,653	66,878	51,751	55,645	75,000

(*a*) Estimate by H. W. Paul, *Eng. Min. Jour.*, Jan. 15, 1916.
(*b*) Included in "Other mines."

The ore deposits of the Ashio group of mines consist for the most part of veins transversing Tertiary liparite (rhyolite) and, to some extent, the Paleozoic sediments of the district. The principal Paleozoic rocks are slate, quartzite and limestone. The liparite is a volcanic neck erupted through the Paleozoic and is more than 2 miles in diameter. The chief constituents of the veins are chalcopyrite and pyrite, with frequently arsenopyrite, blende, galena and pyrrhotite. Occasionally, bornite, chalcocite, cuprite, malachite, pisanite, azurite and native copper are all found in the oxidized zone. Rarely, native bismuth, bismuthinite, wolframite, fluorite, vivianite, ludlamite and apatite are found. As gangue, chlorite, quartz and clay are common, with calcite occurring occasionally.

Overhand stoping is generally adopted at the Ashio mines; underhand stoping and *Nukibori* (special working for richer part of vein) are rarely used. Both hand and machine drilling are done. Among the machine drills are: Walter Leyner, Ingersoll-Sergeant, Sullivan, Flottmann, Little Wonder and others. The ores in the mines are usually classified into two kinds—first-grade and second-grade. The former is rich ore sorted underground and usually averages 12 per cent. copper. About 214 tons of first-grade and 1263 tons of second-grade ore comprise the daily output from the three mines, according to a booklet published this year by the Furukawa company, from which many of the data in this article were obtained.

Smelting is done in four blast furnaces, the matte being converted in three stands of acid-lined barrel-type converters. The ores received at the smelting works are classified into five kinds. These include lump ore, fines, concentrates, slimes and cement copper. The output from the concentrating plants amounts to about 300 tons daily, with an average copper-content of about 11 per cent. Cement copper is obtained from two sources, the mine water and the waters draining from the old dumps. The copper is precipitated on scrap iron, the daily production amounting to about 2.3 tons averaging 66 per cent. Cu. The smelting plant treats annually about 100,000 tons, with an output of over 11,000 tons of copper.

The lump ore is charged to the blast furnaces in the raw state, and the fines are either sintered or briquetted.

The smoke from the smelting plant is passed into a Cyclone dust catcher by means of fans. Having precipitated most of the suspended dust therein, the fume enters the common flue and proceeds to the fume-precipitating chamber, where it is condensed and precipitated by the Rösing wire system. The gases escape through the chimneys after being diluted with fresh air forced in by the fans. The gases as discharged into the air contain about 3 per cent. by volume of SO_2. Care is also taken to prevent damage by the waste products of the precipitating and dressing plants. The tail water from the precipitating tanks and the slimy water from the ore-dressing plants are treated with milk of lime after they have passed through the settling pond.

Power for the Ashio copper operation is supplied from the Hosoo hydro-electric power plant, built in 1905, about 12 miles from Ashio. This plant develops 2500 hp., but it is being enlarged to 10,000 hp. for the purpose of supplying both the Ashio copper mines and the Nikko refining works. Besides the main power plant there are several auxiliary electric- and two water-power plants, near Ashio. The consumption of power in the various departments of the Ashio copper mines is as follows: Mining, 2550 hp.; ore dressing, 800 hp.; smelting, 2200 hp.; miscellaneous, 600 hp.; total, 5150 hp. The Ashio district has rail communication with Tokyo, about 100 miles to the south, by means of the Ashio Ry. and the Imperial Government Ry.[1]

COPPER EXPORTS OF JAPAN
(In tons)

	Europe.	America.	China.	India.	Totals.
1906	23,997	3,628	5,757	82	33,464
1907	13,670	3,569	14,002	410	31,651
1908	25,000	5,515	2,220	2,766	35,501
1909	22,170	9,528	1,589	2,088	35,375
1910	21,116	8,846	957	4,218	35,137
1911	17,288	11,009	3,688	2,322	34,307
1912	23,351	6,917	7,317	805	38,390
1913	19,843	5,543	13,320	3,574	42,280
1914	19,642	5,207	13,577	3,274	41,700
1915	45,140	7,800	1,430	1,220	56,000

[1] *Eng. Min. Jour.*, Dec. 18, 1915.

Mexico (By W. G. Matteson).—The chaotic conditions which featured the mining situation in Mexico during 1914 have grown immeasurably worse during the past year. It may be stated conservatively that 75 per cent. of the mining companies throughout the Republic have suspended operations and have closed their properties indefinitely. The representatives of many foreign-owned properties have left the country on the advice of their respective consuls, and the companies have expressed their intention of indefinite suspension until law and order is absolutely restored.

The year 1915 establishes the record as the period of lowest production and exportation since extensive foreign interests entered the Mexican mining field. Under normal conditions Mexico produces 75,000 to 80,000 metric tons or 175,000,000 lb. of copper yearly; in 1915, the production totaled 30,969[1] metric tons or 68,255,676 lb., a decrease from normal of approximately 60 per cent. The production in 1914 was 36,337 metric tons or 80,086,748 lb. Thus the total output of 1915 represents a reduction of 11,831,072 lb. or 14.5 per cent. from the previous year. These figures are most significant when the high market price of copper is considered.

In the general résumé of conditions, five factors, aside from the activity of the revolutionists, have combined to diminish the scope of or eliminate mine operations. They are lack of supplies, stagnation of railroad transportation, lack of protection, difficulty of securing labor and the currency situation.

Sonora.—A fair estimate would place the copper output of this State at 50 to 60 per cent. of the total for the Republic of Mexico during the past year. In many respects, Sonora is peculiarly and advantageously situated from a geographic viewpoint. Rugged mountain ranges through which no railroad has penetrated isolate it from the other States of the Republic; furthermore, its copper properties are within a relatively short distance of the international boundary and possess such railroad facilities as to permit the transportation of supplies from the United States to most of the large camps within 24 hr.

Despite these natural advantages, the pernicious activities of Francisco Villa's band interfered with operations to such an extent and made production so uncertain that the 1915 output was the lowest in many years. The Cananea Consolidated Copper Co., the largest copper producer in Mexico operated only eight of its mines, the Chivatera, Capote, Elisa, Kirk, Oversight, Puertocitos, Sierra de Cobre, and the Veta Grande. These mines were closed from January to June, operations commencing June 16 and extending to Oct. 24 when they were again

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

interrupted until Dec. 11. Since then, they have been operated continuously. This company has a normal yearly output of 60,000,000 lb. of copper; in 1915, the total production was 16,660,736 lb., 86 per cent. of which came from domestic ores, the remainder from concentrates shipped from other sources. The mines produced 286,158 net tons of ore and 19,526 ft. of development work was recorded. The company's mill and smelter suspended operations for the same period as the mines.

The Pilares mine of the Moctezuma Copper Co. at Nacozari operated intermittently and under difficulties. The burning of the numerous railroad bridges so impaired traffic that no trains were run from January to May. This and adjacent mining companies were forced to pay double duties and taxes to the Carranza and Villa factions. Food supplies were constantly confiscated and if any mines were abandoned, thieves invariably entered the properties and worked the high grade. The Pilares mine and the property of the Nacozari Consolidated were forced to close in October on account of the menace of an approaching Villista army. All foreigners were sent to the United States.

The Moctezuma Copper Co., shipped 30 cars of concentrates a day for a short period during July and August when railroad communication was established.

The Montecristo Sonora Co. at Moctezuma operated on a small scale during the year.

Zacatecas.—The Mazapil Copper Co. of Concepcion del Oro, Zacatecas, one of the largest copper companies in Mexico has still found it inadvisable to attempt operations on a large scale. This rich English corporation has been forced to sustain heavy losses due to enforced activity.

Sinaloa.—At the mining camp of San Blas, operations were practically suspended due to disturbed conditions and activities of the revolutionists.

Chihuahua.—A few properties in this State managed to operate intermittently during 1915 at 50 to 75 per cent. of capacity. The Guggenheim properties were closed, however. Several attempts were made to operate the various smelters of this corporation but the lack of supplies and the poor transportation facilities were too great a handicap. Four furnaces of the American Smelting & Refining Co's. smelter at Chihuahua operated a portion of the time but the others at Monterey, Matehuala, and Aguascalientes were down during the year.

The recent promulgation of revised mining laws now threatens to crush all remaining initiative. The mining corporations have been the main and most profitable source of revenues for the struggling factions during the last 3 years of chaos, double and triple taxation being so common and burdensome as to cause many concerns to close down. In order to prevent suspension of operations with subsequent loss of revenue, Villa ordered a revision of statutes which amounted practically to confiscation of property. Happily this pernicious individual has been all but eliminated from consideration owing to the activities of the United States Government.

Carranza issued a decree on Mar. 1, however, revising the system of taxation and increasing the property tax 700 to 800 per cent. Evidently the purpose of the decree was to break up large holdings and prevent speculation in undeveloped territory since the rate of taxation was increased enormously with the increase in holdings. A modification of this decree was issued on Aug. 31, effecting a considerable reduction.

With an outrageous property tax and a heavy tax on production, payable in gold, the mining industry is laboring under an excessive burden. In the re-habilitation which is necessary after the present civil debauch has been brought to an end, Mexico must depend on foreign capital in generous quantity. With unjust taxation jeopardizing even reasonable profits, it is difficult to see how such capital is going to be attracted.

Even those in intimate touch with the present situation can only vaguely speculate as to the future outlook of the mining industry in Mexico. Many have maintained from the beginning that intervention will be the ultimate and only satisfactory solution. It is surprising to note how many intelligent Mexicans are admitting the plausibility of this view which has gained surprising momentum since the recent vicious political unrest.

A review of the situation is conclusive in two respects: first, the past year has been the most disastrous from the standpoint of operation and production; secondly, the future offers more favorable possibilities now than at any period during the past 2 years. Within the last half year, the Cananea Consolidated Copper Co. has produced at the rate of 5,000,000 to 6,000,000 lb. of copper monthly, which is capacity. In a recent statement, Mr. Geo. Kingdon, General Superintendent of this company, said "We have an abundance of labor at the present time and the situation in this respect is entirely satisfactory. The mining industry in the State of Sonora, particularly in this district, is opening up on the extensive scale and unless something unforseen occurs, the outlook for the mining industry throughout this section for the year 1916 is exceedingly favorable."

Norway.—The total pyrites production for 1914 in Norway was about 430,000 tons, which was taken from the Sulitelma, Stordoe, Bossmo, Foldal, Roestvangen and Röros mines. On this amount 358,114 tons was exported, or about 70,000 tons less than during 1913. For home consumption about 60,000 tons was reserved, and 42,852 tons of purple ore was exported. The total amount of metallic copper produced in the country in 1914 was 2867 tons, and if the copper-content of the pyrites shipped to Sweden, Germany, England and other countries be included, the copper total would be about 11,000 tons. The total value of the copper, and pyrites at Norwegian ports was about 14,000,000 kroner ($3,752,000). Professor Vogt estimates that the Norwegian pyrites exported is about one-tenth of the total of European shipments. He also estimates the German annual production of copper from Norwegian ores in normal times at 22,500 tons, and that of Austria at 3850 tons.

The total number of men employed in the cupriferous mines in Norway during 1914 was 4250. The profits of the Swedish Sulitelma Aktiebolag for 1914 amounted to 1,638,000 kroner ($438,984), and a dividend of 7 per cent. was declared, after 30 per cent. had been written off. Owing, however, to this company's large holding in the Swedish Helsingborg copper-extraction works, where the Sulitelma purple ores are dealt with, the actual profits of the company are much higher. In 1913 the net profit of the Helsingborg Kopparverket was 1,132,000 kroner ($303,376), of which only 450,000 kroner ($120,600) was shown on the books as for Sulitelma account; but as Sulitelma owns nearly the whole of the shares the actual net earnings of the Sulitelma company in 1913 was 2,320,000 kroner ($621,760) or 32 per cent. of the share capital. Of purple ore 80,000 tons was exported to Helsingborg; of pyrites, 125,610 tons was shipped, as against 125,014 tons in 1913; of Elmore concentrates, 13,376 tons, as against 11,472 tons in 1913; and of bessemer copper 1473 tons, as against 1385 tons in the previous year.[1]

The old Enighed copper mine at Högsfjord, which was operated as far back as 1760, was re-opened in February and a shipment of ore was taken out. The result of the exploitation shows the persistence of ore along the strike and in depth. The old dumps also will be worked over.[2]

Explorations in northern Norway have shown the existence of important pyrites deposits in the parish of Grong, a few degrees south of the Arctic Circle. Some of the ore is copper-bearing, while some is free from copper and averages 50 per cent. sulphur. The mines are about 80 km. from the coast and there are as yet no railroads to transport the ore.

The Grong district embraces three main deposits, of which two, Gjersvik and Joma belong to the Aktieselskabet Grong Gruber, while

[1] *Eng. Min. Jour.*, June 26, 1915.
[2] *Eng. Min. Jour.*, June 5, 1915.

the third, Skorovas, is owned by the Norwegian Co. for Electrochemical Industry.

The Gjersvik ore-body is in the form of an oblong-shaped vessel or folding, widest at the bottom and with a gradient of 19°. The mines will supply chiefly lump ore, although there are some fines, for the treatment of which it is intended to build a washing plant. The quality of the ore is similar to that in a number of other pyrites mines in Norway. It carries from 2 to 2.2 per cent. of copper and about 43 per cent. of sulphur. There have also been discovered chalcopyrite lodes estimated to contain about 200,000 tons of ore, for the treatment of which it is intended to erect a smelting works on the spot.

The Gjersvik mines are the smallest of the three deposits, but, on the other hand, the ore is more valuable on account of the high content of copper. The quantity of cupreous pyrites present is estimated at about 1,000,000 tons, besides the above-mentioned 200,000 tons of chalcopyrite ore, and when the mines are put into operation the annual output will be brought up to 60,000 tons.

The Joma deposits should be able to produce 6,000,000 tons at least, although 8,000,000 would possibly come nearer the total, and there is a possibility of the quantity being brought up to 10,000,000 tons, as a depth of 170 m. is not prohibitive to economical exploitation. The mining expenses will be low at Joma on account of the magnitude of the ore-bodies. An additional advantage is that the ore as a rule occurs nearly pure.

About one-sixth of the deposits contains a cupreous pyrite, with 2 per cent. of copper and 43 to 44 per cent. of sulphur. The ore in the remaining parts of the field consists of nearly pure pyrite with little copper, the tenor of sulphur varying between 40 and 50 per cent. and averaging about 44 per cent. The cupriferous deposits can be worked independently to a certain degree, and during the first years the total output of ore will comprise a rather large percentage of cupreous pyrite. But the non-cupreous mineral is, of course, the chief thing, and with this in view the work will have to be carried out on a large scale so as to make it possible to reduce the cost of mining and transport to a minimum. Nearly all the Joma ore will be lump ore, the amount of fines being so small that the erection of a special plant for them is not considered.[1]

As yet the Skorovas deposit has not been as thoroughly explored as the other two deposits, but it is known to have an almost copper-free ore which contains a high sulphur-content, averaging 50 per cent.

Peru (By Joseph T. Singewald, Jr., and Benjamin LeRoy Miller).—Copper is by far the most important metal produced in Peru, exceeding

[1] Andreas Dahl Udhany. The Grong Copper and Pyrites Mines of Norway. *Eng. Min. Jour.*, May 22, 1915.

in value the total of all other metals. After a great depression in the industry during the latter half of the year 1914, the year 1915 was marked by a rapid recovery, until in the latter part of the year copper was being produced at a rate never before known in that country. At the close of 1914 the Cerro de Pasco Mining Co., the largest producer, was producing at the rate of 2,500,000 lb. per month, whereas, at the close of 1915 that company had increased its monthly production to 6,000,000 lb. The Backus and Johnston Co.'s smelter at Casapalca with a capacity of over 1,000,000 lb. was also producing at full capacity. In addition there were in operation the Hauraucaca smelter with a production of about 100,000 lb. per month, and a small 20-ton plant on Lake Huacracocha in the Morococha district. All of these plants are on the Oroya railroad and connecting lines in the departments of Junín and Lima, and they account for nearly all of the Peruvian copper production, although almost all of the departments in the Andean region of Peru maintain a small output. The Cerro de Pasco Mining Co. and the Backus and Johnston are both American concerns and together produce over 90 per cent. of the Peruvian copper. The great development of the copper mining industry in Peru in recent years is, therefore, the result of American enterprise and capital. The Hauraucaca smelter is the property of a Peruvian, E. E. Fernandini, and the small plant on Lake Huacracocha of an Englishman named John Galliver.

The copper ores treated in the above-mentioned plants come from the Cerro de Pasco, Morococha, and Casapalca districts. The Cerro de Pasco smelter receives its ores from both Cerro de Pasco and Morococha; the Backus and Johnston smelter from Morococha and Casapalca; and the Hauraucaca smelter chiefly from Cerro de Pasco and the silver ores from the Colquijirca silver mine.

Two events of unusual interest in 1915 were the incorporation of the Cerro de Pasco Copper Corporation and the passage of a bill levying an export tax on mineral products after they had been exempt for many years. The Cerro de Pasco Copper Corporation took over the interests of the Cerro de Pasco Copper Co. and the Morococha Mining Co., and has a capitalization of $10,000,000 convertible bonds and 1,000,000 shares of stock of no-par value. The bonds are convertible at $30, so that the nominal capitalization is $30,000,000. The mineral export tax bill levies a duty whenever the London price of copper shall exceed £60 per ton as follows: £60–£65 a tax of 15s. per ton, and an increase of 2s. for each additional pound sterling increase in price.

As regards their mineral composition the ores of the Cerro de Pasco and Morococha districts are similar and are characterized by an abundance of enargite and famatinite and to a less extent tetrahedrite. The more commonly occurring copper minerals, chalcopyrite, bornite and chalcocite, are not abundant. In the Cerro de Pasco district the ore-bodies are large replacement masses in rhyolite agglomerates and tuffs and fissure veins cutting these same rocks and a rhyolite area to the west of them. The average grade of the ore of the district is about 11 oz. silver and 7 per cent. copper. It contains less than 1 part gold to 100 parts silver by weight. In the Morococha district there is much greater diversity in the character of the ore-bodies. The country rock of the district consists of limestone, quartzite, porphyry, and peridotite, but the important ore-bodies are confined to the limestone and the porphyry. Most abundant and most productive are fissures veins in the porphyry. At flat contacts with overlying peridotite, the mineralization frequently spreads out along the contact giving rise to extensive sheets of ore called "mantos." The veins in limestone are typically replacement veins and are characterized by frequent enlargements as a result of more extensive replacement along certain strata or at the contact with the overlying rock. The average grade of the Morococha ores is higher than that of the Cerro de Pasco district in both copper and silver, though ores running as low as 5 to 6 per cent. copper are now worked.

The ores of the Casapalca district are more highly argentiferous and run low in copper. Whereas the ores of the other districts are smelting ores, the Casapalca ores require either very careful hand sorting or mechanical concentration before smelting. They carry about 25 to 30 oz. silver and less than 2 per cent. copper. Hand-picked ores may carry as much as 150 to 200 oz. silver. Tetrahedrite is the valuable mineral in these ores.

Russia.—Recent official returns give the production of refined copper in Russia for 2 years past as follows, in metric tons.[1]

	1913.	1914.	Changes.
Urals	17,283	16,760	D. 493
Caucasus	10,003	7,123	D. 2,880
Siberia	5,656	5,616	D. 40
Chemical and refining works	1,380	1,415	I. 35
Total	34,322	30,944	D. 3,378

The decrease in 1914 was chiefly because of war conditions in the latter part of the year. In the Urals the falling off was caused chiefly by shortage of labor. In Siberia there was only a very small change. In the Caucasus, where the loss was greatest, mining and smelting were stopped for a time by actual military operations.

The production of copper in the Ural region of Russia during the

[1] As reported by the *Min. Jour.*, Sept. 11, 1915, p. 446.

first 4 months of 1915 reached a total of 6460 short tons, an increase of 600 tons over the corresponding period in 1914.[1]

The profits of the Kyshtim Corporation last year showed a decline as the result of conditions arising out of the war. The company, however, now seems in a position to recoup these losses by reason of the stimulation of the demand for certain of its products. At the sixth annual meeting held in London recently, Chairman C. F. H. Leslie stated that the company's mines and plants in Russia were now in a position to produce under normal conditions 10,000 tons of copper per year. The war created certain new situations affecting the company and its operations. The company is erecting, at the request of the Russian Government, works for the annual production of about 8000 tons of sulphuric acid. The cost of erecting this plant will be advanced by the Russian Government, and the first 2 years' output purchased at a price that is regarded as satisfactory. The company has also received orders from the Russian Government for pyrites and has increased its output of this mineral to about 1000 tons a week. From one-third to one-half of the employees have joined the colors, but notwithstanding this fact, the production of copper this year up to Oct. 2 was approximately 6000 tons.

In 1914 the abnormal conditions increased the cost of producing copper by about £6 per ton. The profits on copper operations, according to the *Financial Times*, showed a decrease for the year of £67,000; from iron operations a decrease of £32,000; from forests a decrease of £3500, and from barren pyrites a decrease of £2500—a total decrease of £105,-000. The net earnings for the year were approximately 3s. per share as compared with 5s. during the previous year. The dividend recommendation was 1s. per share. Remittances to the English company in the form of gold and silver residues, the product of the electrolytic refinery in Russia, have finally become impossible owing to the order of the Russian Government prohibiting the export of gold-bearing residues. As there is no plant in Russia suitable for separating the refinery products, the directors of the Russian company are negotiating with the Ministry of Finance in Petrograd in regard to a solution of this problem. Nevertheless, since the beginning of the war the British company has distributed in dividends £250,000 without impairing the financial situation of the Russian operating company. The company's operations in 1914 were considerably hampered by the mobilization by the government of more than one-third of the regular employees of the company, the shortage of railway and other transport, and the commandeering of coal supplies. On account of the last circumstance, the company exercised an option on a coal field it had been investigating.

[1] *Consular Rep.*, Oct. 5, 1915, p. 69.

This is about 2½ miles from the railroad and is estimated to contain several million tons of coal above the 200-ft. level. Connections have been made with the railroad, and it is expected that in a few weeks this colliery will be able to supply all the coal required by the company.

During the 12 months ended April, 1915, the company extracted 352,000 tons of copper ore, but disclosed by development and drilling 558,000 tons, so that the ore reserves in April, 1915, were 2,667,000 tons. Since that date a new borehole at the Smirnoff mine has cut the lode at a vertical depth of 1,100 ft., or 500 ft. deeper than the previous depth proved at this mine. The east vein of massive pyrite was 6 ft. in width, and the west vein for 41 ft. contained nearly 3 per cent. copper and about 10s. per ton in precious metals. It was considered that this borehole had indicated an additional 2 years' life to the mine, or a total of approximately 10 years of ore reserves at the present rate of production.

Serbia.—The copper output of Serbia comes from the mines near Bor, in the Department of Timok. The principal mine is the Tehoka Dhulkan and belongs to a group controlled by the Cie. Française des Mines de Bor. There are numerous small deposits of copper in the Balkan states, but this company was the principal producer. Its output in 1912, according to the "Copper Handbook," was 16,699,845 lb. The smelting plant comprised four small water-jacketed furnaces, two of 110 tons' daily capacity and two 210-ton furnaces, and a converter department with one stand and four shells. In the latter part of 1912 most of the employees were ordered into the Serbian army for the Balkan war, and for a long time only one furnace was operated. Near Maidanpek, in the same general district, a 200-ton smelting plant was built in 1907 by a Belgian company, which used the Knudsen process and made a 96 per cent. copper product. This plant has presumably met with the same fate as the Bor property.[1]

Spain.—The copper output of Spain is given in the following table covering the last few years:

COPPER OUTPUT OF SPAIN AND PORTUGAL

(Long tons)

	(*a*) 1911.	(*a*) 1912.	(*a*) 1913.	(*b*) 1914.
Rio Tinto	33,385	39,925	36,320	21,515
Tharsis	3,395	3,375	3,220	3,605
Mason & Barry	2,920	3,540	3,135	2,265
Sevilla	1,530	1,390	1,510	1,435
Other mines	9,700	10,700	9,650	7,695
Total	50,930	58,930	53,835	36,515

(*a*) Henry R. Merton & Co.
(*b*) *Comm. Rept.*, Sept. 2, 1915.

[1] *Eng. Min. Jour.*, Dec. 18, 1915.

The copper district of Spain extends over an area of 52,660 acres, of which only 8073 acres are productive. The greater part, 6548 acres, of the district exploited as in the Province of Huelva, where there are 53 copper mines, including 11 containing pyrites as well. Here are situated the famous Rio Tinto mines, where all the latest improvements for the extraction of metal have been introduced. The older method of smelting has been largely replaced by the sulphur process. As a feature in the recent working of the mines the fact may be recorded that ore formerly neglected, having a lower per cent. of copper, is now being largely and successfully worked, so that if the richer ores that have in the past given such great returns should be found in less quantity there would still be an abundant supply of utilizable ore. This is, however, unlikely to be the case for many years to come, on account of extensive untouched reserves. Spain's output of copper in 1914 was considerably less than during the 2 preceding years, a difference due entirely to repeated strikes at the Rio Tinto mines. It is hoped, however, that the new mining code in preparation will tend to obviate any protracted difficulties between men and employers by the submission of disputes to arbitration. After the United States, Japan, and Australia, Spain stands next in the list of copper-producing countries.

Cordoba.—The Cordoba Copper Co., operating mines near Cordoba, in the south of Spain, during 1915 produced 1766 tons of blister copper as compared with 1941 tons the previous year. During 1914 the company operated at a loss of £4202 due to the low grade of the ore mined during that time. The grade of ore encountered during 1915 was decimal 44 per cent. lower than that of the previous year, but due to the better prices a profit of £10,077 was realized in spite of lean character of the ore.

For the greater part of the period under review the results of the underground operations, as a whole, were disappointing, and the amount of payable ore opened up did not keep pace with the extractions. In consequence of this fact the reserves of ore show a decrease of some 20,981 tons, and now stand at 134,000, of an average value of 2.64 per cent. copper. In the San Rafael section of the mine the results in the deepest level have been disappointing, and much delay has been, and still is, incurred, owing to the exceptionally wet seasons prevailing, the costs of pumping having been over £5000 in excess of 1914. In the 1280-ft. level west payable ore was discovered in a northern portion of the lode, and this has been driven upon in ore for a distance of 335 ft., the ore being, for that distance, of a value of about 3 per cent. In the eastern section of the mine on the San Rafael lode at eastern shaft a new, level at a depth of 1515 ft. has been commenced, and is being driven on a wide lode formation, and the prospects of making discoveries are considered to be good. The 1115 east has disclosed two shoots of ore, the first 129 ft. long averaging 3.18 per cent., and the second 318 ft. long averaging 1.23, in each case the width of the lode being from 3 to 4 ft. Further east, again, on the same lode San Arturo shaft has been sunk to a depth of 618 ft., and has reached the horizon of the 1115 east of eastern shaft. The drivage of the 820- and 1115-ft. levels further east from San Arturo shaft will be watched with interest, as they will penetrate a promising part of the property where extensive old workings occur at surface. The year's work on the Excelsior and San Lorenzo lodes has resulted in most satisfactory development, which is continuing up to the present time. The 850-ft. level at Excelsior has been driven 416 ft. in ore averaging 1.82 per cent. over a width of 3½ ft., and a further 121 ft. has averaged 3½ ft. in width, carrying 3.4 per cent. copper. In the 850-ft. level east at San Lorenzo we have had lengths of 138 ft. assaying 1.69 per cent., 30 ft. assaying 3¼ per cent., and 188 ft. assaying 3½ per cent. over, in each case, about 3½ ft., and further, since the report, 127 ft. has been driven on the continuation of the same shoot of ore, on lode 3¾ ft. in width assaying 3½ per cent. The developments in these two outlying mines are always viewed with especial interest, as they generally supply us with a good proportion of direct-smelting ore, which, of course, costs less to treat than that which has to be closely concentrated.

Mason and Barry.—The annual report of this company for 1915 states that the total quantity of ore broken and raised at the mine was 192,942 tons, as compared with 259,238 tons in 1914. Shipments during the same period including the ore from the cementation work amounted to 168,118 tons, as against 257,616 tons in 1914. The company made a profit of £59,737 from its operations for the year, and will pay a 30 per cent. dividend.

Pena Copper Mines.[1]—This company was formed in London in 1900 to acquire a copper and sulphur mine in the Huelva district of Spain, that had previously been worked by a Belgian company. The ownership and control has been on the Continent, and Heinrich Schreck is manager. Small dividends were paid from 1903 to 1906. Of recent years there have been difficulties with the Rio Tinto company over the selling and railway contracts, and capital has had to be provided to help to finance an alternative railway route. During the construction of the railway, shipments were suspended, and it was only at the end of August, 1914, that they were resumed. The report for the year 1914 now issued shows that during the 4 months 10,472 tons of cupriferous pyrite was shipped,

[1] *Min. Mag.*, Dec. 1915.

together with 8532 tons of sulphur ore, and 11,754 tons of leached cupriferous pyrite, being a total of 31,028 tons. The production of copper precipitate was equal to 597 tons of fine copper. The profit on the sale of produce was £7731. Against this £2970 was spent in the London office, £3844 paid as English and French taxes, and £4028 as interest on loans, leaving a debit balance of £2683. At the mine development on the twelfth level was continued, and investigations were made with a view to discover the faulted portion of the lode.

Huelva Copper & Sulphur.[1]—This company was formed in 1903 to acquire the Monte Romero and other pyrite mines in Huelva province, southern Spain. Four years ago, H. F. Collins was appointed manager, and he proceeded to erect a copper smelter so as to produce metal instead of relying on the export of pyrite. The report for the year to June 30 last shows that this policy has been to advantage, for in spite of many adverse circumstances connected with the war, the profits have increased. During the year, 49,508 tons of ore was smelted yielding 1222 tons of blister copper. In addition 190 tons of fine copper was produced by the cementation process. The cupreous pyrite exported was only 3549 tons as compared with 18,340 tons the year before. The accounts show an income from the sales of copper and ore of £89,291, and the net profit was £5440. The sale of outlying properties brought £21,178, which has been applied to writing down the loan raised for completing the erection of the smelting plant. The company's finances are now in good shape, and divisible profits may be expected shortly.

Esperanza Sulphur & Copper.[2]—This company was formed in 1906 to acquire the Esperanza, Forzosa, and Angostura pyrite mines in the south of Spain. T. D. Lawther is general manager. The capital is £350,000, and there are £47,020 out of £100,000 debentures outstanding. Small dividends were distributed for the years 1908 to 1912. The report for the year 1914 shows that the output was greater than during the previous year, when stoppages occurred owing to floods and shaft-repairs, but on the other hand deliveries could not be made to French and Belgian buyers after the outbreak of war. At the Angostura mine 47,426 tons was raised, and at the Esperanza-Forzosa group 63,497 tons. The reserves are estimated at 340,000 tons and 483,000 tons respectively. Developments prove that the north ore-body at the Angostura has narrowed to merely a stringer 120 ft. below the fourth level, and that the same condition obtains on the sixth level at Forzosa. Diamond-drilling and sinking are being continued in the hope that the ore-bodies will widen with depth. The shipments from the port of Huelva

[1] *Min. Mag.*, Dec. 1915.
[2] *Min. Mag.*, Mar., 1916.

were 98,751 tons, a decrease of 20,107 tons as compared with 1913. The ore sold but not delivered amounted to 16,000 tons of cupreous pyrite and 48,000 tons of sulphur ore. The profit for the year was £10,821.

Rio Tinto.—The report of the Rio Tinto Co., Ltd., for 1914–15 was read at the meeting of the company at London, on Mar. 21,1916. A half-year's dividend of 2s. 6d. per share on the preferred shares and a final dividend of 35s. per share on the ordinary shares, making with the interim dividend paid in November last, £2 15s., or 55 per cent. for the year 1915, were declared. The company was operating its properties throughout the year, although it was stated that ocean freight and fuel were so high as to increase materially the expenses. The advancing prices of copper, however, more than compensated for the high cost of producing it.[1]

OUTPUT OF RIO TINTO MINES
(In long tons)

Year.	Pyrite for Shipment.	Ores for Local Treatment.	Total Mined.	Average Copper Contents, Per Cent.	Copper Produced at Mines.	Pyrite Sold.	Washed and Other Sulphur Ores Sold.
1903	688,919	1,229,619	1,918,538	2.390	21,565	667,748	118,174
1904	672,344	1,276,475	1,948,819	2.340	21,218	663,744	157,810
1905	627,336	1,202,768	1,830,104	2.363	19,530	660,724	308,184
1906	655,328	1,268,388	1,923,716	2.411	21,287	632,307	477,843
1907	641,858	1,265,090	1,906,948	2.417	21,251	607,944	619,814
1908	604,275	1,115,610	1,719,885	2.265	24,256	589,815	668,477
1909	604,799	1,184,188	1,788,987	2.349	24,364	600,946	569,604
1910	637,020	1,509,945	2,146,965	2.097	22,790	578,443	683,605
1911	649,215	1,536,390	2,185,605	2.144	21,880	662,259	841,964
1912	698,399	1,708,573	2,406,972	2.180	25,623	668,861	977,812
1913	652,168	1,207,403	1,859,571	2.190	21,062	635,900	825,408

The average price received for copper was £72 12s. as compared with £59 9s. 4d. in 1914.

For the first time the annual report omits quantity of copper sold. In 1914 there was omitted the quantity of sulphur ore delivered, and this omission is continued in 1915. After setting out average market price of standard copper in 1915 and 1914—1915 showing an increase of £13 3s. 4d. per ton—all that the report says is conveyed in two lines as under: "The increase in price of copper was, however, largely counteracted by increases in costs, especially those for freight, fuel and iron."[2]

Tharsis.—The report of the Tharsis Sulphur and Copper Co., Ltd., Huelva, Spain, for the year ended Dec. 31, 1915, shows that the total quantity of ore raised during the year was 401,150 tons, as compared with 357,295 tons in 1914, an increase of 43,855 tons. The shipments were in all 546,536 tons, as compared with 517,688 tons in 1914, an increase of 28,848 tons. The pyrites shipped, including washed ore, amounted to

[1] *Eng. Min. Jour.*, May 6, 1916, p. 827.
[2] *Min. Eng. World.*, May 6, 1916, p. 875.

544,995 tons, as compared with 501,037 tons in 1914, an increase of 43,958 tons. The shipments of copper amounted to 1541 tons, as compared with 1611 tons in the preceding year.

Owing to the scarcity of labor and other conditions, it was found difficult to keep the metal works fully employed, but the quantity of ore treated did not fall much short of that for the previous year. The new mechanical roasting furnaces continue to give good results, and a great reduction in the consumption of coal is effected therewith. The expenditure on new installations at various works, with a view to insuring economical working, continues to be heavy; the sum of £23,679 8s. 8d. has been added to the works-property account during the year. The amount written off for depreciation was £10,994 11s. 6d. The net profit for the year, together with the balance of £35,971 7s. 3d. brought forward from 1914, as shown by the profit and loss account, amounted to £139,262 7s. 10d. The directors recommend that the sum of £125,000 be appropriated for a dividened of 4s. per share, free of income tax, equal to 10 per cent. on the capital of the company, and that the balance of £14,262 7s. 10d. be carried forward to the credit of the next year.

The amount of sulphate of copper that can be expected this year from the two companies producing this chemical in Spain is about 10,000 tons and that already imported on hand may be estimated at 1000 tons. The Spanish Government, it is stated, has bought 1000 tons from the United States and is negotiating for the purchase of as much more so that viniculturists may count upon a supply of 13,000 tons of sulphate of copper.

There are about 1,250,000 hectares (3,088,800 acres) in Spain devoted to vineyards, and the average amount of sulphate of copper required for their treatment is 25 kilos per hectare. Accordingly, the full amount required would be 31,250 tons, or over two and two-fifths times as much as now available.[1]

Sweden.—Sweden's copper production has declined from 44,274 tons in 1875 to 5458 tons in 1913. During the past year, however, there has been a revival of this industry. Lack of transportation facilities and high freight rates hampered Swedish manufacturers in securing their customary supplies from the United States, and this spurred many to see if it were not possible to mine a sufficient quantity of copper in Sweden to cover the domestic needs. Considerable difficulty was encountered in installing the proper machinery and in getting the right sort of labor, so that whatever increase there may be in the amount of copper mined in the Kingdom will be but temporary, and as soon as the war is over American copper will promptly take its old place in the im-

[1] *Comm. Rept.*, May 18, 1916.

portations of Sweden. [Official American statistics show that in the fiscal year ended June 30, 1915, the United States shipped to Sweden 34,545,504 lb. of copper pigs, ingots, and bars, valued at $4,815,949, against 16,005,094 lb. (value, $2,362,204) in 1914, and 9,080,914 lb. (value, $1,471,885) in 1913; 519,980 lb. of copper rods and wire, valued at $69,041, against 3608 lb. (value, $827) in 1914 and none in 1913; and $244,181 worth of other copper manufactures, against $51,403 worth and $10,196 worth in the 2 preceding years, respectively.]

In 1865 Sweden imported only 196 tons of copper; in 1913 the amount imported was 9560 tons. In 1865 the amount of copper exported from Sweden amounted to 1487 tons; in 1913 the amount exported was 1401 tons. These figures indicate that in a crisis like the present Sweden could mine sufficient copper for its own needs. As showing the importance of the copper mine at Falun in the past, it may be stated that during the history of the mine no less than 40,000,000 tons of ore have been mined, from which 500,000 tons of copper have been extracted. The copper produced in Sweden to-day is extracted from burnt pyrites obtained in the manufacture of sulphuric acid.

It is reported that a number of new copper-ore deposits have been found in the neighborhood of Bjornange, in the County of Are, Province of Jamtland. Ten applications have been made to the Government authorities in order to investigate and possibly mine these deposits, in case they are found to be of sufficient importance. It is claimed that an analysis of these deposits shows anywhere from 10 to 20 per cent. of copper.

Copper ore (chalcopyrite) is at present mined extensively in only one district, the Falun, Province of Dalecarlia. This is the largest copper-ore deposit in Sweden and supposed to be one of the largest deposits of chalcopyrite in the world. This mine has been worked for nearly 700 years. Other copper deposits are found at Garpenberg in southern Dalarne, at Tunaberg in Sodermanland, Bersbo in Ostergotland, and Areskutan in Jamtland. The last-named mine is commonly known as an American mine from the fact that some American capital is invested in it and also because it is partly fitted up with American machinery.[1]

Pyrometallurgy of Copper in 1915

By L. S. Austin

Progress in 1915.—The development of concentration by flotation has modified the methods of metallurgical treatment. A self-fluxing ore for

[1] Ernest L. Harris, Consul, Stockholm, *Comm. Rept.*, p. 331, Oct. 22, 1915.

example of 1.6 per cent. copper would, if smelted, still produce a slag of 0.3 per cent., that is, there would be a 20 per cent. loss in the slag alone. Now if such an ore were treated by flotation the loss would be perhaps 10 per cent. Such concentrate, roasted and smelted in a reverberatory would, to be sure, undergo further loss, but altogether less than if directly smelted.

The roasting of fine flotation concentrates has made more important the recover of the consequent flue dust. At the International Smeltery, Miami, Ariz., the dust-chambers have been omitted in favor of a Cottrell plant, where the recovery may be regarded as complete.

The estimated cost of the improvements at Anaconda is $4,000,000, at Great Falls $1,750,000, part of which is for new reverberatories and a new roasting plant. In the beginning of 1915 the recovery at both of these plants was 78 per cent. of the copper content. It is expected to raise the recovery to 91 per cent. by the use of the flotation process on material leaving the concentrator. At Anaconda, in particular, there will be no first-class ore; all ore will go to the concentrator, and the blast furnaces can be dispensed with. To take care of the increased volume of fine concentrate produced by flotation, a new roasting plant, No. 2, has been constructed containing 28 roasting furnaces. To smelt the total roasted product there are eight reverberatories each of 650 tons daily capacity.

Two years ago at these works it was planned to obtain closer savings by leaching, but due to the higher savings by flotation, leaching was carried no farther. Comparing recoveries in September, 1913, with those in the same month in 1915 and on a basis of 14 cts. per lb., it was reckoned that the gain of valuable metals formerly lost in the tailings would have been 50,000,000 lb. of copper, nearly 1,000,000 oz. silver and about 5000 oz. of gold, equivalent to $7,250,000, and that with an investment of $5,000,000 in new plant. The seven new 20-ft. upright Great-Falls-type converters will give an output of about 22,000,000 lb. of copper monthly. The converter slag, heretofore sent to the blast furnaces, will be smelted in No. 9 reverberatory furnace at the converter plant, along with converter by-products or secondaries. It will treat daily 700 tons of slag and 350 tons of fine ore.

Copper smelting has reached its highest development and, except for self-fluxing ores (especially those which carry just enough sulphur to produce a limited matte-fall) and for the heavy non-concentrating sulphides, is on the wane. Especially in the case of blast-furnace work is it destined to fall from its front rank. Nevertheless, it has its field and new smelter construction proceeds.

Smeltery construction in Arizona has been active. The International

Smelting & Refining Co. is erecting five out of an installation of six furnaces for drying concentrates preparatory to treatment in three reverberatory furnaces, the matte then being reduced to blister copper in four upright 12-ft. basic-lined converters. It will be noticed that the material is dried, not roasted, since it contains no more sulphur than is needed to produce a suitable matte-fall.

At Clarkdale, Ariz., the United Verde Copper Co. uses six Wedge furnaces for roasting. The calcine is treated in reverberatory furnaces, the raw ore in blast furnaces. Matte is reduced in basic-lined converters.

The Calumet & Arizona smeltery and the Arizona Copper Co. at Clifton have perfected conveying-belt methods of handling materials. In the latter, the eight Herreshoff roasters have had external fire-boxes added to kindle and sustain the roasting when the sulphur content gets low.

At the Copper Queen smeltery, Douglass, Ariz., the addition of seven new McDougall furnaces makes a total of 16.

Smelting Furnace Reactions and Products

The Messiter System of Ore Bedding and Reclaiming.[1]—W. A. Clay ably sets forth the advantages and adaptability of this system, which has been described in Mineral Industry, **16,** 349; **18,** 191; **19,** 199 and **21,** 228. He shows that:

A bed, though partly made of proper composition for smelting, may be at any time brought into use, added to, and the composition corrected while using.

The imperfections in ordinary bedding are that changes must be made as a bin runs out; that bins vary in composition; that the thickness of a layer may vary; that the face of the ore may cave, giving for a short time too much of the top layers; that the charges also vary; that the workman cannot work uniformly; that coarse and fine also vary.

On the other hand, Mr. Clay has perhaps not sufficiently considered irregularities due to having to use the last portion of a bed made by the Messiter system, both in composition and in the sizes of the ore, the difficulties due to exposure to rain and to freezing and to the cost of installation. It is but fair to say that even this cost is but half that involved where the ore is carried in storage bins.

Pyrite Smelting at Mt. Lyell.[2]—To Robert Sticht's remarks in Mineral Industry **23,** 208, regarding the smeltery at Mt. Lyell, Tasmania, we add the following:

The furnaces are 17 ft. 8 in. long by 54 in. wide, and are blown with 20,000 cu. ft. of air per min. at 64 to 66 oz. pressure. In 1903 the Mt.

[1] *Min. Eng. World,* **43,** 98.
[2] *Bull. Amer. Inst. Min. Eng.,* Apr., 1915, 742.

Lyell Co. took over the mines of the North Mt. Lyell Co. which contained an abundance of ore carrying 70 per cent. silica, eminently suited for smelting with the Mt. Lyell Co.'s pyrite, which, from its initial content of 4.5 per cent. copper, had come down to 1.5 per cent., with much of 0.5 per cent. only. Both kinds of ore are pure, free from lead and zinc, and with not too much alumina and heavy spar. The low-grade pyrite of 0.5 per cent. is smelted with North Mt. Lyell ore averaging 6 per cent. to make a charge of 2.15 to 2.25 per cent. copper, and from this is produced a matte of 45 to 50 per cent. copper at one smelting, being a concentration of 20 into one, and putting through 1000 tons daily. Some limestone is used on the charge; there is about 7 per cent. Al_2O_3 and 0.35 to 0.45 per cent. copper in the slag. The fuel is an inferior coke containing 10 per cent. water and 16 per cent. ash. It is fed to the long walls of the furnace rather than spread evenly. When smelting Mt. Lyell pyrite the coke was as little as 0.1 per cent. later 1.5 per cent. was used, but now, using silicious ore, the percentage has risen to 3.5 per cent. to 5 per cent. In the older practice, however, barren quartz was added on the pyrite charge. Lumpy material is fed, and a smelting column of 18 ft., is carried. It is in contemplation to increase the pressure to 96 oz. and the smelting column to 25 ft. though this height may prove to be excessive.

If a tube 2 to 4 in. in diam. is allowed to descend with the charge, a continuous stream of sublimated sulphur issues, in a highly heated state, transparent and oily looking. At 2 ft. from the pipe it shows a flame of burning sulphur, with flecks of yellow sulphur vapor, which also take fire. In the space above the focus 95 to 96 per cent. of the iron is oxidized, and any oxygen still escaping, burns the free sulphur above. It is possible to keep down the percentage of fines and so do better smelting by adding coarser ore to the charge when that percentage runs over 10 per cent. In charging, the coke is first pushed in from the charge-plate by a mechanically operated blade, and is followed successively by the pyrite, the siliceous ore, the limestone and the converter slag. The furnace is fed from each side in succession. Flue dust accretions, etc., are similarly fed. Charge materials are delivered in two-wheeled hand carts so that the charge can be readily varied, as is often necessary. The feed-plates project about 10 in. into the furnace, though from 9 to 15 in. has been tried. The center line of the furnace should be kept porous and less blast be permitted at the sides; ideally the blast should rise equally over the charge.

The pyrite and limestone on the charge is constant, the siliceous ore and coke are varied. To raise the grade of the matte the siliceous ore is increased, and this will occur 1½ to 2 hr. after the charge is put in.

Frequent matte assays are made by the shift bosses at the furnaces, and they aim to keep the matte at about 45 per cent. in copper.

Smelting at the Tennessee Copper Smeltery.[1]—An oxygen efficiency of 87.5 was attained, but then no excess air is allowed, due to the fact that the gases are used for acid making, and must be low in oxygen.

Metal Losses in Copper Slag.[2]—Frank E. Lathe gives a review of the published data on the losses of copper in slags, and adds to it an account of his own investigations.

Haywood shows that the copper loss in the slag increases regularly with the grade of matte produced, and that a higher silica in the slag makes it cleaner. Thus a 25 per cent. matte resulted in a 0.33 per cent. copper loss while a 50 per cent. matte made a loss of 0.50 per cent. in the slag. With silica under 30 per cent. the loss was greater by 0.15 than when over 33 per cent.

Wright finds the same—increase with increasing grade of the matte, but between 20 per cent. and 37 per cent. there is less variation, there being an average of 0.30 per cent. copper in the slag. He denies that the copper exists as prills of matte, but that part of it was chemically dissolved.

J. Parke Channing and J. E. McAllister think that a considerable part of the copper enters the slag as oxide or silicate.

C. A. Heberlein, while smelting an ore of but 0.3 per cent. copper and considerable gold and silver, recovered 98 per cent. of the gold (the silver was lower) and 78 per cent. of the copper.

F. A. Sundt states that the percentage of copper in the slag depends on that in the charge.

Wanjukoff, from laboratory experiments on artificially made slag deduces: That slags are cleaner when ferrous oxide is replaced by lime and alumina, and that when zinc oxide replaces lime, the copper-content rapidly rises. (This corresponds well with smelting experience.)

John W. James treated converter slag poured into a reverberatory by use of green poles and charcoal. The contained copper was reduced to 1.25–1.50 per cent. By throwing a little pyrite upon the charge the copper was reduced to 0.7 per cent. He concluded that the poling reduced the copper oxide or silicate, and the pyrite furnished matte to further take out copper.

Hoffman's figures for modern reverberatory slag are rather inconsequent. The matte varies from 35 per cent. to 45 per cent. Cu, the slags from 35 per cent. to 45 per cent. SiO_2. Within these limits of well-melted mattes and slags, furnacing must have a great influence in production of a clean slag.

A. J. Bone comparing the smelting of raw pyrite with that of a low-

[1] *Bull. Amer. Inst. Min. Eng.*, Apr., 1915, p. 753.
[2] *Eng. Min. Jour.*, **100**, 215, 263, 305.

grade matte, which was run with addition of limestone, found that the slag was cleaner in spite of the larger copper-content of the charge. (This may have been due to the use of limestone.)

Frank E. Lathe now discusses the Granby practice and gives the results of his investigations on slag constitution.

The furnaces, originally 44 by 160 in., and of 9-ft. smelting column, have since 1909, been lengthened to 266 in. and deepened to 12 ft. 10 in. This resulted in more uniform running, greater tonnage, less coke needed, a hotter matte and slag, and, owing to less oxidizing action in the furnace, a lower grade matte and a more siliceous slag. The slag is better settled, due to the use of three small settlers in series.

In the period 1909–1912, when producing matte of 35 to 40 per cent., a slag of 43 per cent. silica would carry 0.25 per cent. copper, one of 46 per cent. would retain but 0.21 per cent. When producing a lower grade matte of 28 to 34 per cent. copper the slags were cleaner especially when

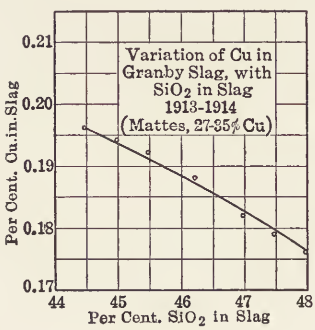


FIG. 1.

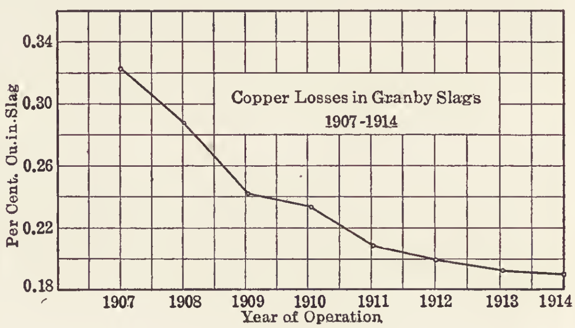


FIG. 2.

their silica-content had risen to 46 per cent., there then being but 0.19 per cent. copper retained.

The practice at the Granby smeltery is well shown in Figs. 1 and 2. The slags of not over 45 per cent. were the more fluid, and settled better than the more siliceous ones. Still Fig. 1 shows the cleanest slags at 48 per cent. SiO_2. Referring to Fig. 2, there was an improvement even before the furnaces were changed in 1909, and thereafter the slag dropped from 0.24 per cent. copper in 1909 to 0.19 per cent. in 1914.

Mr. Channing had suggested a method of determining the quantity of copper oxide in the slag on the assumption that matte particles present carry the same copper, gold and silver as the furnace matte, and that more copper than indicated by this proportion must be in oxidized form. Thus, the gold per ton of copper in Granby matte is 4.412 oz., in the slag 1.398 oz. Hence the copper as matte in the slag is $\frac{1.398 \times 100}{4.412} =$

31.7 per cent. leaving 68.3 per cent. for copper in oxide form. To check this result the copper oxide was directly determined by digestion with dilute sulphuric acid with fairly concurrent results.

At the Great Falls smeltery, Mont., the total copper shown in the slag was 0.28 per cent. and as oxide 0.14 per cent. or 50 per cent. of the total. However, the percentage of sulphur on the charge is fully five times greater than at the Granby smeltery.

At the Washoe Works, Anaconda, the reverberatory slag showed that copper oxide was 74 per cent., and in the blast furnace, 64 per cent. of the total content of the slag in copper.

In molten furnace products it was experimentally determined that copper oxide as well as copper silicate will form in presence of matte. The oxide is more easily reduced than the silicate.

Slag-cleaning Methods.[1]—Frank E. Lathe discussed methods of obtaining low copper slags.

Losses of suspended matte particles may be lessened by securing fluid slag, either by composition or by running it hotter. A slag of low specific gravity separates better; on the other hand, increase of FeO may improve fluidity, but also increase specific gravity. The best results are secured by a compromise.

At the Grand Forks smelter settlers in series have proved more effective than a single large one. As many as seven in a row have been there tried, and some matte has been recovered even in the last one. Practice there has settled upon having three in series. It has been thought that there is a benefit in cascading from one settler to the next. The average temperature of the issuing slag from the furnace is 1275° C., though the slag will flow at 1100° C.

E. J. Carlyle has made the suggestion that in a reverberatory furnace a wall or barrier of refractory material be built near the front to hold back the main body of matte, but over which the slag can flow. Between this wall and the skimming door pyrite is dropped on the bath of slag to clean it. The low-grade matte thus produced would be separately tapped. A side-door behind the dam would be available to remove floaters.

It is a question whether the custom of pouring the converter slag into the blast-furnace forehearth is good practice. Certainly some matte should be settled and some copper oxide reduced. Returning such slag to a reverberatory seems more satisfactory especially where raw sulphides are used.

Fluming Granulated Slag.[2]—Furnace slag at Anaconda has been granulated and flumed to waste by water from the concentrator, which

[1] *Eng. Min. Jour.*, **100**, 305.
[2] *Eng. Min. Jour.*, **100**, 763.

carried mill-slime. This slime coated the dump at the point of discharge and the water-borne slag was carried a great distance upon the dump. Now, because of the installation of the flotation process, the slime has been removed, and the water of the discharge, now slime-free, sinks, leaving the granulated slag to pile up at the end of the flume. Cars of 20-yd. capacity, drawn by an electric locomotive, remove the slag. The sides of the cars drop outward, forming with the bottom an extension to dump the material farther from track rails.

Blast Furnaces

Smelting at Anyox, British Columbia.[1]—The ores smelted are of variable analysis. One hundred tons of custom ore are treated daily. The acid and basic company ores can be combined to make a self-fluxing ore, but of late, the tendency has been toward a high silica-content, hence the limestone flux, and also the coke percentage has to be increased. With the earlier experience with ores having lower silica-content it was possible to use barren quartz, so that then smelting proceeded more smoothly. Anyox ores carry 8 to 9 per cent. Al_2O_3, have 5 per cent. moisture, and 30 per cent. of fine of less than ½ in. The slag, as now made, contains SiO_2, 37 per cent.; FeO, 42 to 43 per cent.; CaO, 6.0 per cent. and Al_2O_3, 7.5 per cent.

Originally, the first matte of 10 per cent. was converted directly, but it has been found more economical to raise its grade by concentration in the blast furnace. The first matte was run into long beds, dug up by pick and shovel, and sent back to the furnace. This proved to be expensive and a mechanical method was substituted as follows:

The edges of a bed are broken by powder to give the scraper a chance to loosen the matte, then a back-haul scraper-bucket is pulled along the bed by means of a donkey-engine, digging up the matte and scraping it up an incline to a structure situated on a track at a higher level. Here it is dumped into a railroad car, and so carried to the charge-floor of the furnaces. By this new arrangement as much as 600 tons daily can be loaded by six men, including the hoist man. The objection made is that the proportion of fines is too great.

The first matte is re-smelted with siliceous ore to produce a matte of 20 to 25 per cent. Cu. From this grade the converting department can produce copper at the rate of 3,000,000 lb. monthly.

Recently the Traylor Engineering & Manufacturing Co. has furnished a fourth furnace, side-dumping cars of the Anaconda pattern, a matte-casting machine and silica-bins for directly charging ore to the converters.

[1] *Bull. Amer. Inst. Min. Eng.*, Apr., 1915, 753; *Eng. Min. Jour.*, **100**, 804, 1050.

There has been also installed an agglomerating plant where converter slag, flue dust and similar material can be mixed for use at the furnace.

Blast-furnace Spout.[1]—At Great Falls, Mont., a spout, welded by oxyacetylene flame is in use, a cut of which is given in Fig. 3. The figure shows not only the spout and top-jacket, but parts of the water-jacket, tuyère, crucible and crucible plate and the settler with its double lining. The water-cooled top-jacket having been placed, the spout supported below by a 4 by 1-in. bar, is tied to the crucible frame on each side by a 1-in. rod. A cast-iron dam-block is bolted to the front of the spout, on which is set a water-cooled lip, making a 13-in. trap above the tap-hole. The pipe connections are also welded on. The furnace is drained through the lower tap-hole of the dam-block.

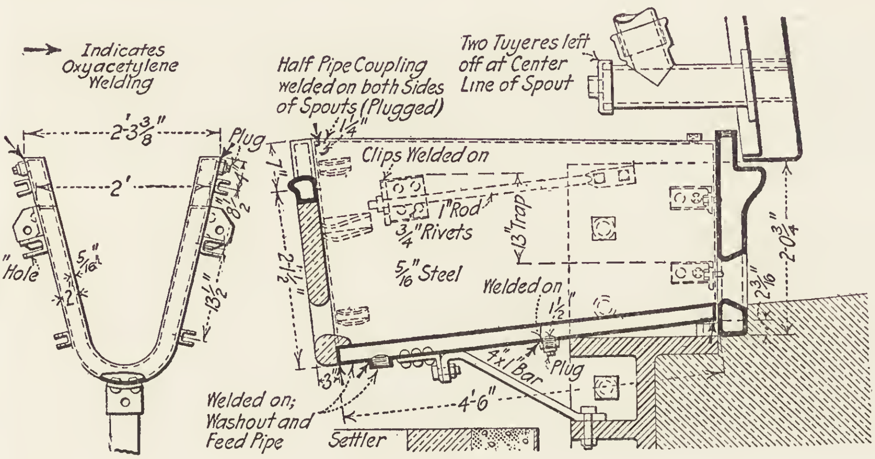


Fig. 2.—Welded furnace spout.

Reverberatory Furnaces

We note that 1 to 1½ per cent. sodium carbonate has been added to the crushed quartz for reverberatory-furnace bottoms, and these bottoms are even superior to those generally made, not only in durability, but in strength and hardness.

Coal-dust Fired Reverberatory Furnaces.[2]—When side-charging was adopted at Anaconda, banking the charge against the sides nearly to the spring of the arch, formed an obstruction, so that the matte could not be tapped at the sides. The matte tap-hole was then removed to the front, 18 in. below the regular slag outlet, the charge working nicely. Side-charging protects the sides, but the angle between the roof and sides is still corroded.

[1] *Eng. Min. Jour.*, **99**, 741.
[2] *Bull. Amer. Inst. Min. Eng.*, May, 1915, p. 1174.

By putting the coal-conveying apparatus outside the reverberatory-furnace building, it has been possible to lengthen the furnaces to 144 ft. At the same time the width has been increased to 22 ft.

These large furnaces are put in operation as follows: A slow wood fire is started, a little coal fire for 4 days, then for a day 51 tons, and on the day following 46 tons of coal on a charge of 345 tons. In 4 days thereafter the charge has risen to its normal amount of 613 tons, using 86 tons of coal, a fuel ratio of 7.1 to 1.

To get complete combustion, and to have the ash so fine that it will be carried out of the furnace by the draft, almost all the coal should be ground so fine as to pass a 200-mesh screen. Particles of coal 1/10 in. diam. are not completely burned even in this long furnace, particles settling within the furnace. Some 2 or 3 bu. of a light ash are taken out at the front of the furnace in 24 hr., equal to about 400 to 500 lb. An advantage of the use of pulverized coal is that a coal containing a high percentage of pyrite can be used, which in grate-firing, causes trouble from the formation of clinkers. Again, grate-firing means that 25 to 33 per cent. of the coal is lost by radiation from the sides and grate of the fire-box; this is obviated in coal-dust firing.

Side-fettling obviates the delay due to hand-fettling, where 10 per cent. of the time is lost.

At Garfield, Utah, oil has been replaced by powdered coal. The experience has been that about 10 per cent. more heat units are needed when using coal, but this varied, so that, using a short-flame lignite, the difference might amount to 25 per cent. but, with a bituminous coal, the difference would disappear. When using oil, the aim was to clear the flame at 30 ft. from the front. At charging time the flame carries to the front, then gradually shortens. Draft at this point is 0.15 in. of water; the escaping gases carry 2.5 per cent. oxygen, equal to 12.1 per cent. excess air. When operating with coal, the flame is larger but does not reach the boilers; the gases carry 5 per cent. oxygen equivalent to an excess of 25 per cent. of air.[1]

Reverberatory Smelting of the Nevada Consolidated Copper Co.[2]—R. E. H. Pomeroy describes the No. 2 furnace, and its operation at McGill, Nev. It is oil-fired, 132 by 19 ft. hearth dimensions, with the roof rising 7 ft. above the slag-line at the fire-end, then, beyond the charge hoppers, dropping to 4 ft. The flue at the verb is narrowed to 24.3 sq. ft., leading to two 400-hp. Stirling waste-heat boilers.

California crude oil of 16.5° Bé. is used, heated by steam to 200° F. (93° C.) just before use. The oil is fed by gravity at 34 lb. per sq. in. to

[1] The Garfield reverberatories are 112 by 19 ft., with the arch 7 ft. 10 in. high, fed by hoppers in two rows 6 ft. apart. The aim is to smelt 400 tons daily as being the most economical in fuel and in wear of the furnace brickwork.

[2] *Bull. Amer. Inst. Min. Eng.*, Feb., 1915, p. 445.

seven low-pressure blast burners of the Steptoe type. The blast for the burners is delivered at 40 oz. pressure per sq. in., thus supplying 10 per cent. of the theoretical air, the remainder being drawn in through 15 by 12-in. burner-holes in the firing wall. The draft at this point is 0.18 in., at the outlet flue 1 in. and at the stack 1.4 in. of water.

Fig. 4 is a chart showing the gradient of flame temperatures. This shows that the maximum permissible temperature of 3070° F. (1690° C.) is attained at the second side-door, 21 ft. from the burners. As seen in

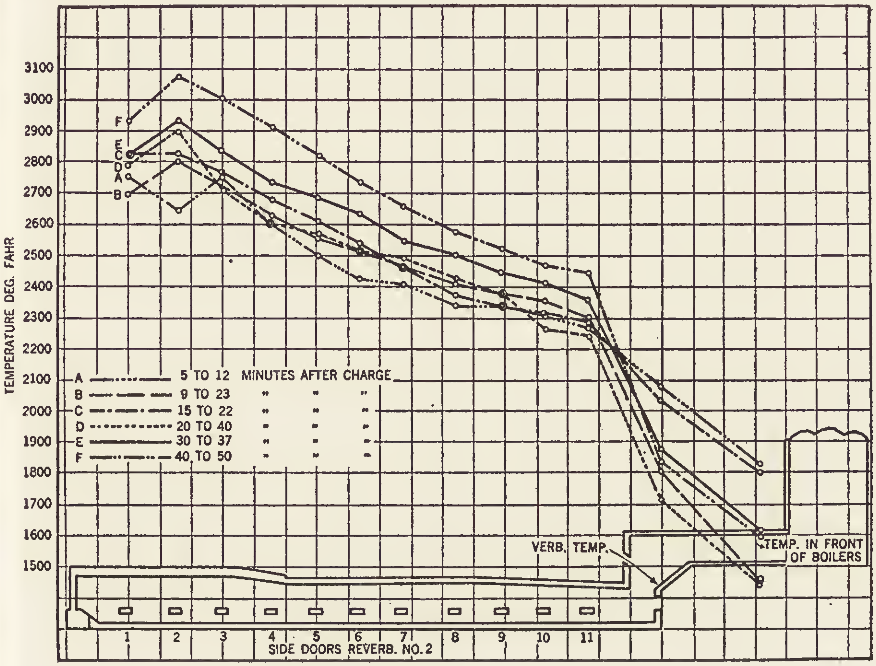


Fig. 4.—Side-door temperatures of reverberatory furnace.

curve *A*, the temperature falls for 10 min. after a charge is dropped to 2750° F. (1510° C.). The gradient is quite uniform, not varying more than 150° F. between charges. The sharp drop after the last furnace door is due in part to the disappearance of the flame, to air leakage around the skimming door, and to radiation from the flue, though this latter is lessened by covering it with 2 in. of asbestos painted with heavy asphaltum.

The waste-heat boilers recover 34.35 per cent. of the total heat. No attempt is made to regulate the steam requirements by the oil burned, the deficiency being made up by hand-fired stand-by boilers. Thus the oil for smelting is used with economy.

Variations, due to steam-shovel work in mining the original ore, make a concentrate which may vary from 4 to 10 per cent. copper and from 24 to 34 per cent. sulphur, and a smelting of from 4 to 8.5 tons into one, thus introducing difficulties in melting down, such as are not encountered in the treatment of a uniform concentrate. The concentrates in this plant are delivered direct to the furnaces without opportunity of bedding or grading, and any fluxing has to be made by additions of limestone.

Fettling is done by hand. As a foundation and below the slag-line, the heavy secondary material from the converters (brick, sweepings, etc.) is thrown against the side, and above this is put daily about 30 tons of mill-slime or siliceous concentrate, carrying 3.3 per cent. Cu and 6.6 per cent. SiO_2. The side-door openings are piled full with fettling, so that no doors are needed.

The molten converter slag is poured from 10-ton slag-cars standing on the reverberatory charge-floor, through a grating thence by a 16-in. cast-iron pipe, into the furnace. The grating holds back the slag-pot skull which is broken up on the grizzly and drops into the furnace.

During a period of 4 months in 1914, the average composition of the charge was calcine, 60 per cent.; cold converter secondary material, 7.6 per cent.; hot converter slag, 12.4 per cent.; slimes for fettling, 5 per cent.; limerock, 12.7 per cent.; flue dust from roaster flues, 25 per cent. Of the total of matte and slag produced 22 per cent. was matte of the composition Cu, 27.5 per cent. and Fe, 40.8 per cent. The slag, considering the amount of converter slag treated, is quite clean, containing but 0.3 per cent. Cu. It carries SiO_2, 42.2 per cent.; Fe, 28.4; CaO, 9.0; Al_2O_3 6.8 and S, 0.4 per cent.

During the 4 months above mentioned, the solid charge (smelting molten slag) was 600 tons daily, the slag 85 tons. There was used 385 bbl. of fuel-oil, being 0.642 bbl. per ton of solid charge. Crediting the waste-heat boilers at 14 lb. of water evaporated per lb. of oil, the heat recovered was 34.4 per cent. of the total oil used, which thus reduces that used for actual smelting to 0.421 bbl. per ton of solid charge.

The slag is skimmed three times in an 8-hr. shift. The matte bath, about 3 ft. deep, is kept as near the skimming-plate level as possible to facilitate the absorption of the heat by the matte between charges, this heat being then given up to the cold charge above when the latter is dropped. The solid charge, 20 to 25 tons at a time, is dropped through four charge-holes at intervals of about 50 min. At the roasters the crushed limerock is fed into the next to the lowest hearth, and thus is well mixed with the calcines. Hence, when the calcines are dropped and spread out upon the molten bath, there is a rapid evolution of CO_2 from the limestone, resulting in a thorough mixing and intimate contact of the elements of the charge and so eliminating floaters, though these sometimes form from the siliceous fettling.

A furnace campaign is of 170 to 200 days. The repairs then generally consist of renewal of 20 to 30 ft. of the roof at the fire-end; the side walls are patched and some brickwork added at the front end.

Mr. Pomeroy considers that efficient combustion is attained by using a burner which will properly atomize the oil and by carefully regulating the draft.

Furnace operation is promoted by preliminary mixing of the charge, an addition of enough coarsely crushed limestone, maintaining a deep bath of molten matte, frequent skimming, and maintaining smelting conditions, ignoring the waste-heat boilers.

The furnace campaign is prolonged by having the furnace roof high, by careful fettling, and by frequent charging of well-mixed materials.

Gas-fired Reverberatory Furnace.[1]—C. Offerhaus described the type of furnace as installed at Sulitjelma, Norway, intended for treating 70 to 90 tons daily of Elmore concentrates. The coarse ore is smelted by the Knudsen process (MINERAL INDUSTRY, **17**, 315).

Since the company has cheap water-power, there was no advantage to be gained by installing waste-heat boilers, and so, to utilize the heat, a regenerator for preheating the combustion air was put in. Hence the furnace is not reversible as are the gas furnaces at Great Falls, Mont.

An average analysis of Elmore concentrates is as follows: Cu, 6.5 per cent.; S, 35.3; Fe, 36.8; SiO_2, 12.7; Al_2O_3, 4.83; CaO, trace and MgO, 0.72 per cent. It will be seen that this will make a basic slag, even when quartz is added. The oil used in concentrating forms a film which covers each grain, making it hard to roast. The same difficulty exists when attempting to roast in pots by the Huntington and Heberlein process or when using a Dwight-Lloyd machine. The wet concentrates are weighed, dried in a rotary drier, using the hot gases from the roaster. They are then elevated to the hoppers of a large eight-hearth Wedge roaster which, after doubling the speed of the rabble arms, has an actual roasting capacity of 47 tons daily, including 10 per cent. of ground quartz.

The calcines are transferred by 1000-lb. hopper-bottom steel cars to the reverberatory-furnace charge-floor.

The furnace itself is 76 by 19 ft. outside dimensions, and has five doors per side. Referring to Fig. 5 there are three Schmidt and Desgraz gas producers, 8 ft. inside diameter, of 8 to 10 tons capacity, though but 5 tons is gasified daily, yielding a gas having 2 to 4 per cent. CO_2 at an average temperature of 500° C. at the furnace valves. By the gas valves *E* it is distributed from the back-wall ports to the roof ports of the

[1] *Eng. Min. Jour.*, **100**, 1033.

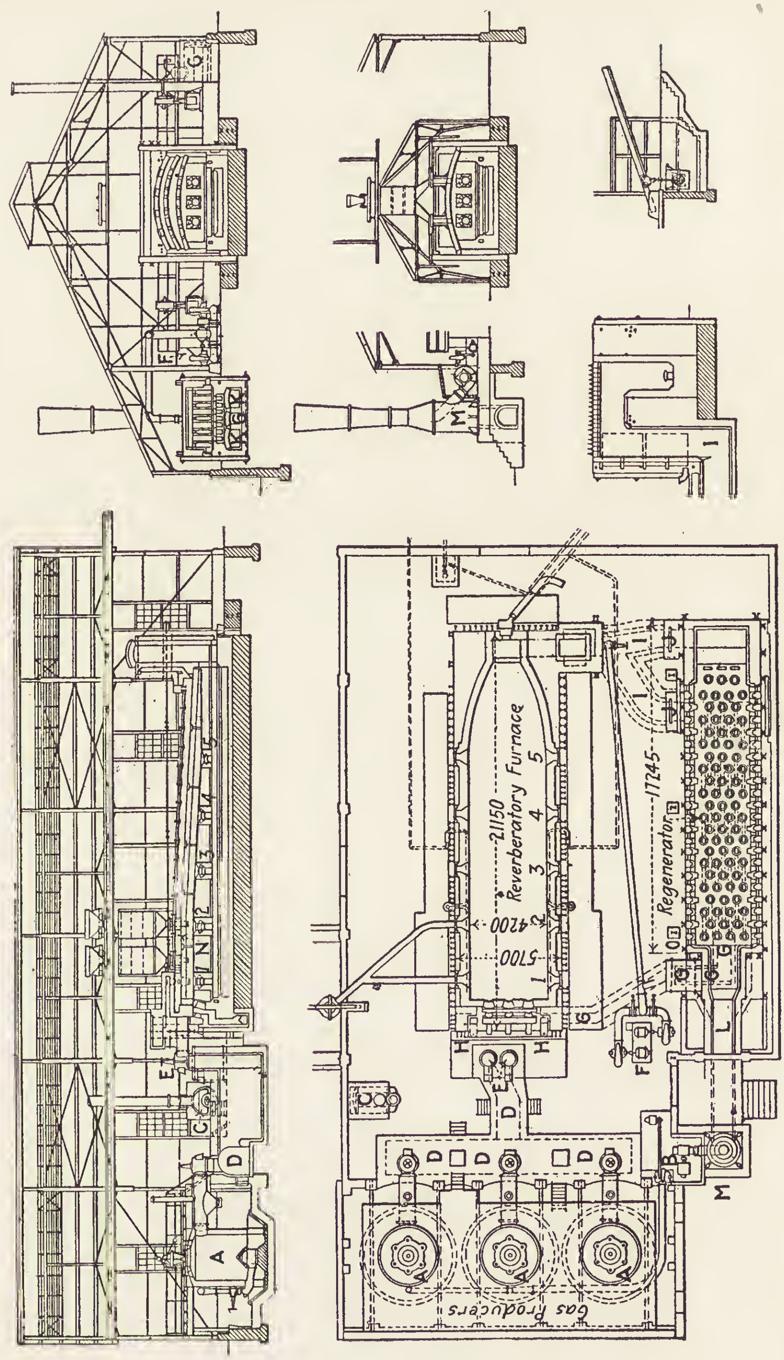


FIG. 5.—Reverberatory smelting plant at Sulitjelma, Norway.

furnace. The gases pass away from the furnace by the branching flue *II* and in them at *JJ* are two valves, so that they may deliver to the regenerator by the flues *KK*. The furnace gases leave the regenerator by the flue *L* to the ejector-shaped stack *M*, where a jet of air, created by the fan *B*, drives them upward into the exterior air.

Air for combustion, is delivered by a fan *F*, in part to the double roof of the furnace, in part to the regenerator. The air delivered to the regenerator passes through vertical tubes made of "chamotte" to the channel *G* and thence to the back end of the furnace. The furnace gases circulate outside the tubes. At No. 1 furnace-door the temperature is 1500° C., at No. 5 door 1275° to 1300° C., at the front 1200° C. The gases enter the regenerator at 1000° to 1100° C., and leave at 390° C. The preheated air at *G* is 500° C. and that in the roof is 420° C. By valves at *HH*, regenerator air can be added to that in the double roof.

From the back to the fourth door the furnace is lined to above the slag-line with magnesite brick backed by water-cooled 2-in. pipes laid in the brickwork. The hearth at the back is 12 in. deep, consisting of ground magnesite 6 parts to granulated slag 1 part. The front of the furnace (hearth and side walls) to the fourth door may be of any kind of refractory material.

There is produced a slag containing silica, 32.5 per cent.; FeO, 51.5; Al_2O_3, 10.8; CaO, 1.1; MgO, 2.1; S, 2.0 and Cu, 0.5 per cent., and a matte of 35 per cent. Cu. Matte from the Knudsen converters, containing 50 to 55 per cent. Cu, is sometimes charged bringing up the grade to 40 to 45 per cent. copper. The furnace is skimmed once in 8 hr. It is repaired monthly, being first tapped dry, and the fettling is done with the magnesite mixture already described. In case a tap-hole is frozen, it is opened up as follows: A ½-in. iron pipe, 10 to 12 ft. long, is connected by a rubber hose to an oxygen flask; the other end is then heated red hot in the furnace, applied to the tap-hole, and a stream of oxygen admitted at 90 lb. pressure. By the rapid burning of the red-hot iron so much heat is generated as to quickly melt out the tap-hole.

The gas-flues must be cleaned every fortnight, the gas-ports weekly. Cleaning the flues delays the furnace 5 hr. but the ports are cleaned while the furnace is running.

Fettling Reverberatory Furnace Walls.[1]—At the Copper Queen smeltery, Douglass, Ariz., F. Rutherford, since he is smelting a basic charge, uses for fettling, ores running as high as 35 per cent. Fe, as low as 25 per cent. SiO_2, and with 15 to 18 per cent. S and 5 per cent. Cu. The front half of the furnace is lined with magnesite brick, but the rest of the wall is

[1] *Eng. Min. Jour.*, **100**, 843.

protected by the heavy sulphide ore, which in any case should carry enough sulphur to matte all the copper.

Cathode Re-melting Furnace.[2]—At one of the eastern refineries a reverberatory furnace 40 by 19 ft. and 7 ft. high has a waste-heat boiler of 11,500 sq. ft. of heating surface, equal to 1150 hp. The furnace has turned out 350 tons of copper in 24 hr., and it is expected will ultimately turn out 400 to 450 tons. It has in connection a casting machine producing 90 tons hourly of wire bars.

Waste-heat Boilers at Chrome, N. J.[2]—Clarence L. Brower describes the experience in the use of waste-heat boilers in connection with reverberatory refining furnaces. The trials were with 75-ton, 100-ton, and 200-ton furnaces in succession, but these installations were a failure, the boilers not producing enough steam to pay for their maintenance.

After careful consideration it was concluded, that to make waste-heat boilers pay in copper-refining furnaces, the boilers should be set as close

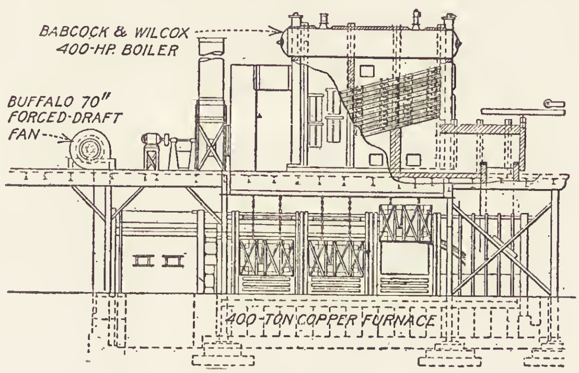


Fig. 6.—Waste heat boilers, Chrome, N. J.

to the furnaces as possible, eliminating long and crooked flues, omitting the emergency stack and doing away with dampers. The boiler is accordingly set on top of the furnace, and at one of the reverberatories a Sturtevant economizer has been installed. Fig. 6 shows a view of a 400-ton copper furnace, furnished with a 400-hp. Babcock and Wilcox boiler. The furnace is operated with a forced draft from a closed ash-pit where the pressure is 0.73 in. of water. A suction-fan takes away the furnace gases to a small stack, so that the draft entering the boiler is 0.318 in., and leaving it 1.051 in. water. At a 24-hr. trial, made May 27, 1914, 27 tons of coal containing 92.8 per cent. fixed carbon and volatile matter and 7.1 per cent. ash was burned, which, besides melting the charge, developed nearly 400 hp. equal to 6.2 lb. water per lb. of coal. The flue

[2] *Bull. Amer. Inst. Min. Eng.*, May, 1915, 1178.
[2] *Eng. Min. Jour.*, **99**, 893.

gases contained 8.84 per cent. of CO_2. They left the furnace at 855° C. and the boiler at 336° C.

Coal-pulverising Plant at Anaconda.[1]—E. P. Mathewson describes the new plant just built to supply coal-dust fuel to the nine reverberatory furnaces.

Smelteries

Anaconda Reduction Works.[2]—Improvements amounting to $4,000,000 have been made in 1915 at this works.

The recovery on ores at the beginning of the year was about 78 per cent. of the copper content; by the use of flotation processes it will be raised to 91 per cent. Under the new system calculated to be in operation in 1916, there will be no first-class ore from the company mines. All its ore will go to the concentrator, which will be raised from about 12,500 tons per day to 15,000 tons. Tailings from coarse concentrate will be re-ground to pass a 60-mesh screen, and this product will be treated by flotation, making a concentrate of about 8 per cent. copper and a tailing of but 0.1 per cent.

The field of the blast furnace and of briquetting will be greatly restricted, if not eliminated. To roast the original concentrates, those which will be obtained from the first-class ore, and the flotation concentrates, a new roaster plant (No. 2) has been built, containing 28 furnaces 22 ft. 6 in. diam. These will be charged from storage bins by a belt-conveyor system. The calcines will, however, be hauled to the reverberatories, by the present tramming system. The new reverberatories, 22 by 144 ft., each have a capacity of 650 tons daily, so that the present furnaces will have a capacity two and one-half times greater than before the enlargement from a little over 100 ft. long.

The barrel converters will be replaced by seven 20-ft. upright Great-Falls-type converters, which together will yield 22,000,000 lb. of copper per month.

In the converter building has been installed a reverberatory of 153 ft. by 21 ft. 6 in. It will receive 700 tons of molten converter slag and 350 tons of fine ore per day.

To furnish additional air a turbo-blower of 35,000 cu. ft. per min. has been put in. It is direct-coupled to a steam turbine which makes 3400 r.p.m. and has proved to be highly successful.

Canadian Smelteries.[3]—The following table gives furnace and converter data:

[1] *Eng. Min. Jour.*, **100,** 45.
[2] *Min. Eng. World*, **42,** 367.
[3] Copper Industries of Canada, *Bull.* 209, *Met. Chem. Eng.*, **13,** 16.

Company.	No. Furnaces.	Size Furnace, In.	Ore Column, Ft.	Capacity per Day, tons.
Canadian Copper Co.	5	50 by 204	14	400
	1	50 by 240	14	550
Mond Nickel Co.	2	50 by 240	12	550
Consolidated Mining & Smelting Co.	1	42 by 210	8	350
	1	42 by 360	8	650
	1	42 by 264	8	460
	1	42 by 420	8	700
	1	50 by 420	8	875
Granby Consolidated Mining & Smelting Co.				
Grand Forks	6	44 by 266	12	500
	2	48 by 260	12	550
Anyox	4	50 by 360	12	750
British Columbia Copper Co.	2	51 by 360	12	800
	1	51 by 240	12	500
Tyee Copper Co.	1	42 by 120	6	200
	1	42 by 160	6	500

The Canadian Copper Co. has five Pierce-Smith basic converters, 10 ft. by 37 ft. 2 in. long.

The Mond Nickel Co. has two Pierce-Smith basic converters, 10 ft. by 25 ft. 10 in. long.

The Granby Consolidated Mining & Smelting Co. has at Grand Forks, three Power and Machinery Co.'s acid-lined converters, 84 by 126 in. long; at Anyox, three Great-Falls-type basic converters, 12 ft. diam. by 5 ft. 9 in. high.

The British Columbia Copper Co. has two Allis-Chalmers acid-lined converters, 84 by 126 in. long.

Trail Smeltery.[1]—The Consolidated Mining & Smelting Co. has made alterations at their copper plant.

Two of the blast furnaces have been increased from 25 to 35 ft. in length, and from 42 to 50 in. in width at the tuyères. They show an increase of 60 to 80 per cent. in capacity, and a resultant saving in labor and coke per ton of ore smelted.

The Granby Consolidated Co.[2]—This company smelted 1,098,020 tons, including 24,583 tons of foreign ore, at its two plants at Grand Forks and Anyox for the year ending June 30, 1915. The production was 26,638,912 lb. refined copper, or 1.21 per cent. on the ore smelted, also 377,881 oz. of silver and 31,388 oz. of gold. At Granby the cost of production is 10.66 cts. per lb. of copper, the cost of smelting per ton of ore being $1.187 as against $1.214 for 1913. The coke used per ton of ore was 13.17 per cent.

British Columbia Copper Co.[3]—Supplementing the descriptions in Mineral Industry, **18**, 212 and **20**, 239, we add further particulars:

The plant was closed down in August, 1914, due to the low price of copper at the beginning of the European war.

[1] *Min. Eng. World*, **42**, 32.
[2] *Met. Chem. Eng.*, **14**, 14.
[3] Trans. *Amer. Inst. Min. Eng., Bull.*, July, 1915.

The three blast furnaces smelted daily 2250 tons of ore (6.62 tons per sq. ft. of hearth area), carrying 0.85 per cent. Cu, at a smelting cost of $1.18 per ton. The plant was operated by 130 men (including repairs) being a labor efficiency of 17.5 tons per man per day. Each blast-furnace shift requires 21 men.

In 1910 the blast furnaces were widened to 51 in. from a former width of 48 in.

Each blast furnace has a bottom lining of chrome and clay gannister, topped by fire-brick set on end. The side lining is of two courses of chrome brick, backed by crushed quartz for 22 in. above the bottom, then with silica brick or fire-brick to the top, except at the inlet and outlet points, where the chrome lining is retained.

The blast is supplied by three No. 10 Root blowers, each of 25,000 cu. ft. per min. capacity, driven by a 300-hp. electric motor. Through a common header any blower can be used for any furnace.

An average furnace charge is as follows:

Ore.	Lb.	SiO_2.		Fe.		CaO.		S.		Cu.	
		Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.	Per Cent.	Lb.
Mother lode..........	2500	32	800	18	450	22	550	2	50	1.0	25.0
Rawhide.............	1600	36	576	16	256	19	304	3	48	1.2	19.2
Napoleon............	500	30	150	30	150	7	35	17	85	0.2	0.5
Republic, SiO_2........	400	80	320	......	.....	7	28	.....	......	.....	......
Total............	5000		1846		856		917		183		44.7

This gives 4300 lb. of slag, carrying 0.23 per cent. or 10 lb. Cu. leaving 34.7 lb. for the matte. Some 88 per cent. or 160 lb. of the sulphur is volatilized, leaving 23 lb. for the matte. A matte of 42 per cent. Cu. was produced and a slag containing SiO_2, 42.7; FeO, 25.3; CaO, 21.2; Al_2O_3, 9.0 and Cu, 0.23 per cent. The variable factor of the charge is the mother-lode ore, the silica varying from 17 to 38; the iron from 15 to 33, and the lime from 7 to 22 per cent. Due to sudden changes in its composition the furnaces need constant watching.

On account of the small bins used assay results can not be made in time, so that smelting is regulated by the physical appearance of the slag.

Some 12 to 14 per cent. of coke is used, carrying 20 to 28 per cent. of ash. The cooling-water for the three furnaces is given as 4000 gal. per hr.

The converters are lined with siliceous ore from Republic, Wash., or from the Snowstorm mine, Idaho, mixed with local clay. A lining will last two or three charges, each charge consisting of two or three 5-ton ladlefuls of matte blown to blister copper at one heat. The converter slag was returned by railroad cars to the main smelter bins. The converter gases pass by a sheet-iron flue to a dust-chamber of 281 sq. ft. cross-section, thence to a 6-ft. stack, 75 ft. high. The flue dust is fed back to the converter charge.

Some 30,000 lb. of blister copper is produced daily, moulded into 360-lb. ingots, and is shipped East for refining. This copper contains 7 oz. Au and 30 oz. Ag per ton.

The converter department, when running two 8-hr. shifts, needs 21 men.

The electric power, purchased from the West Kootenay Light & Power Co., is brought on 60,000-volt high-tension lines to the Greenwood substation, then transformed to 220 volts for use at the works. When a lower voltage motor is used, it is further transformed. The plant is kept in repair by a force of 15 men.

Equipment of Smelteries in Arizona.[1]—Dr. James Douglass gives the following synopsis of the equipment of these smelting plants.

Copper Queen smeltery, Douglas. Ten blast furnaces, 18 and 20 ft. long by 42 in. wide; three reverberatories 91½ ft. long by 19 ft. wide; seven 12-ft. upright converters; 16 roasters.

Calumet & Arizona smeltery, Douglas. Two blast furnaces 40 ft. long; four reverberatories 100 ft. long by 19 ft. wide; six 12-ft. upright converters; 12 roasters.

United Verde smeltery, Jerome. Four blast furnaces 27½ ft. long by 48 in. wide; four reverberatories 100 ft. long by 19 ft. wide; six 12-ft. upright converters.

Arizona Copper Co. smeltery, Clifton. Four reverberatories 100 ft. long by 19 ft. wide; six roasters; six 12-ft. upright converters.

Works of the American Smelting & Refining Co., Hayden. Two reverberatories, 112 ft. long by 19 ft. wide; eight roasters; three converters.

Detroit Copper Mining Co. smeltery, Morenci. One large blast furnace; four small converters.

Old Dominion smeltery, Globe. Six blast furnaces; two 12-ft. upright converters.

Shannon Copper Co. smeltery, Clifton. Three blast furnaces; two converters.

International Smelting & Refining Co.—Three reverberatories; six roasters; six converters.

Humboldt smeltery, Humboldt. One reverberatory, 19 by 60 ft., one 19 by 100 ft.; one Wedge roaster; two converters.

[1] Internat. Eng. Cong.; *Met. Chem. Eng.*, **13**, 904.

Arizona Smelting Co.'s Works.[1]—This smeltery at Humboldt, Ariz., began renovating its plant in 1915. The first unit of the plant is as follows:

One eight-hearth Wedge roaster, including the top drying hearth. The daily charge for this is 30 tons concentrates, 55 tons smelting ore and 25 tons of limestone, and the analysis of this charge is Cu, 6 per cent.; Fe, 20; Insol., 34; CaO, 12 and sulphur, 20 per cent. This is roasted down to 4.2 to 5.5 per cent. sulphur. The charge is self-roasting, though there are oil burners that can be used if needed. One reverberatory of 60 ft. by 19 ft. hearth dimensions.

Arizona Copper Co. Smeltery.[2]—In addition to the description in MINERAL INDUSTRY, **23**, 232, we add details as follows:

A broad site has been chosen below Clifton, now having 5 miles of standard railroad trackage and 2 miles for electric motor handling; also abundant dump room. The bedding conveyors are 188 ft. long supported by covered steel galleries 24 ft. high. Each belt travels 400 ft. per min. and spreads 150 tons per hr. There are two Robbins-Messiter reclaiming machines. From a machine the ore drops on a return trench-conveyor 198 ft. long to a transverse 20-in. conveying belt 145 ft. long, to a 20-in. incline belt conveyor 370 ft. long with 86 ft. rise, to a 20-in. cross-conveyor 51 ft. long, and to two 20-in. belt conveyors each 109 ft. long; these latter delivering through grids to the 70-ton hoppers of the Herreshoff roasters, 21 ft. 6 in. diam. by 18 ft. high, and having one drying hearth and six roasting hearths. The shafts and arms are cooled with air at 1¾ oz. pressure. Each roaster takes 3 hp. to drive it. The roaster building is 64 by 114 ft.

Sampled ore from the mill goes by two conveying belts, respectively 114 and 200 ft. long, to the bunker bins built across the end of the ore-beds, to any one of which it can be delivered by tripper. A 20-in. reclaiming belt, 165 ft. long, feeds from the bins to a 20-in. inclined conveying-belt, and to a 20-in. cross-conveying belt, 165 ft. long, serving the reverberatory-furnace fettling-bins, those over the converters, and those for the agglomerating cones.

The reverberatory-furnace building is 114 by 179 ft. Two furnaces out of the three are usually run. Slag is tapped into 20-ton motor-tilted slag-cars.

The converter building has a space of 58 by 379 ft. in its main aisle, its crane runway extending into the reverberatory-furnace building. Converter equipment includes three stands and four shells of basic-lined upright 12-ft. converters. Converter slag is skimmed into 5-ton ladles

[1] *Min. Eng. World*, **42**, 19.
[2] *Min. Eng. World*, **43**, 205.

and may be charged to the reverberatories, or taken to the agglomerating machines, and the nodulized product sent to the reverberatory furnaces.

All furnace gases pass to a central stack 305 ft. high and 22 ft. inside diam., with a 4-in. lining of acid-proof brick. The outside is of brick and tile, laid for 75 ft. from the top with special acid-proof brick.

International Smelting & Refining Co.'s Works, Arizona.—This takes care of the output of the Inspiration and Miami mills. It has been under construction for the past year and was started late in May. It was built at a cost of $2,220,000. It has six Wedge roasters used for drying the concentrate before sending it to the reverberatories. The ore is not roasted as it contains barely enough sulphur to yield a matte of the proper grade. The dust from these Wedge furnaces is caught in a Cottrell treating plant. Oil is used for fuel throughout and all smelting is done in the three reverberatories.

Calumet and Arizona Smeltery.[1]—C. A. Tupper gives a detailed illustrated description of the belt-conveying systems to which the reader is referred.

A total of 23,721 ft. of conveying-belts is used, varying in width from 20 in. to 30 in., operated at a speed of 150 to 400 ft. per min., and of from 50 to 200 tons hourly capacity. To operate them there are employed 48 electric motors of from 5 to 50 hp. which have a speed of 860 r.p.m. Ore and coke of sizes, up to 12 in. diam., are transported. The fine ore is under ⅝-in. mesh size; the coarse ore runs up to 4 in. diam.

Skulls from ladles in the converter department are crushed by a McGregor breaker, and conveyed by belt to deliver to a loading chute, to 50-ton railroad cars, thence to the ore-receiving bins.

The calcine and flue dust are handled in self-propelling larry cars which transfer at a level to command the reverberatory charging openings, these being along the center line of the furnace.

United Verde Smeltery.[2]—A fully illustrated description appears in Mineral Industry, **23,** 232. To this we add new data as follows:

Of the ores treated the most important are: (1) an iron sulphide of Fe, 30 to 40 per cent.; S, 35 to 45; SiO_2, 4 to 10 per cent. and with copper varying from low to high; (2) a chalcopyrite in a schist gangue; (3) an iron-stained quartz in quartz prophory, some of which is siliceous enough for converter flux; (4) oxidized ores near the surface carrying gold and silver.

Ore to the plant is delivered in 50-ton. pressed-steel cars, 30 being devoted to this service. Limestone is obtained from a deposit at the 900-ft. level of the United Verde mines, whence it is readily trammed out at the 1000-ft. level.

[1] *Min. Eng. World*, **42,** 4; Mineral Industry, **23,** 242.
[2] *Min. Eng. World*, **42,** 717.

A transverse conveying-belt at the end of the ore-storage bed discharges to a cross-conveyor, which takes the ore to the charge-car track under the bins, or to the conveyor which serves the crushing plant.

The Wedge roasters have reinforced concrete hearths. Each roaster has a capacity of 96 tons in 24 hr. A 30-hp. motor drives the six furnaces. For starting them, until they become self-roasting, oil burners are used.

The reverberatories treat both calcines and oxidized mine ore. Slag is drawn off into slag-cars, and drawn by electric locomotive to the dump.

The charge for the blast furnaces will consist of rich oxidized and sulphide ores and some limestone. Ore and flux from the bins is brought to the furnace in 4 to 6-ton side-discharge cars. The four blast furnaces are supplied with air at 40-oz. pressure from five Root blowers, two of 400 ft., two of 300 ft., one of 224 cu. ft. per revolution. Three are driven by electricity; one 400-ft. blower is driven by a 16 by 32 by 36-in. tandem compound engine, and one 300-ft. machine by a 3-cylinder Diesel engine.

The converters are charged from overhead bins with spouts leading to the converter mouths. A McGregor skull-breaker is used. For the converters there are four blowing units. Two are compound duplex blowing engines, having 60-in. air cylinders of 21,000 cu. ft.; one a compound duplex blowing engine, having 44-in. air cylinder of 15,000 cu. ft.; also one turbo-blower of 24,000 cu. ft. of air per min., all at 16 lb. pressure.

A large part of the electric power is furnished by the Arizona Power Co.; the rest is generated at the steam plant. Boiler-feed and cooling-water are taken from the Verde river from a concrete intake in the bed of the stream. Aldrich pumps are used for this service, having a daily capacity of 1,500,000 gal. The suction pipe consists of 16 and 20-in. galvanized spiral-rivetted pipe; the discharge of the pumps is of 14, 12 and 10-in. spiral-rivetted pipe.

Air, at 2 lb. pressure, is furnished by a two-stage compressor with a capacity of 3000 cu. ft. of free air per min.

Copper Queen Reduction Works.[1]—Supplementing the description in Mineral Industry, **15**, 259 and **21**, 256, we give the following:

Ore, to be directly smelted, is mixed at the Sacramento Shaft, Bisbee, by means of a Stephenson-Adamson belt-conveying, distributing and loading plant. At the smelting plant it is stored in five beds of a total capacity of 50,000 tons. Converter slag, custom ores and some roasted sulphides are added to the beds. Two beds are emptying while three are in process of making. Taking one dipper of 1¼ cu. yd. per car, a charge-train is loaded in 10 min. For each train is needed a motorman and swamper, for each steam shovel an engineer and fireman, also two shovellers to keep the ore cleaned up in the pit. The trains, uncoupled

[1] *Min. Eng. World*, **43**, 725; *Eng. Min. Jour.*, **99**.

from the charge-locomotive, are left at the furnaces, where they are handled for unloading by a special 15-ton locomotive. The charge-locomotive then takes the empty train, now awaiting it, back to the loading beds.

Nacozari concentrates, containing 32.5 per cent. sulphur, are unloaded into hopper-bottom bins, and are thence drawn upon a conveying-belt, and by bucket-elevator to the automatic tripper conveyor which keeps the roaster hoppers supplied.

In the past year there has been added seven 18-ft. MacDougal roasters, making 16 in all. They put through at first 68 to 78 tons daily, but now no more than 58 tons roasted to 11 per cent. sulphur, and the best duty is calculated at 50 tons per furnace. Flue dust is made to the amount of 5.2 per cent. of the charge. It is collected in a special dust-chamber of hollow tile and steel, 42 ft. wide, of a sectional area of 1200 sq. ft. and 144 ft. long, hung with Rösing wires suspended at 3¾-in. intervals from horizontal chains hung at 6-in. centers. Baffle-plates at each end of the chamber distribute the current.

From the roasters the calcines are drawn off into special cars of vertical cylindrical type, having conical bottoms closed by valves.

There are ten blast furnaces all 44 in. wide, five 20 ft. and five 18 ft. long. The tuyères are 4 in. diam. spaced at 12-in. centers. The blast pressure is 30 oz. delivered at constant volume from 11 Connersville blowers, each furnace being separately supplied, but so that the air can be by-passed to another furnace if necessary. The settlers are 20 to 23 ft. long by 10 to 12 ft. wide. Slag is removed in 14-ton slag-cars. The jacket water amounts to 400 gal. per min. escaping at 46° C.

The blast-furnace flue dust contains 7.5 per cent. Cu. Owing to the fine, friable charge, a pressure of not more than 27 oz. is carried. With the new dust-chambers, where the current velocity is less than 5 ft. per sec. the flue dust is now 3.92 per cent.; formerly it was 7.59 per cent. of the charge. Due to more sulphur in the charge than formerly, the matte-fall reaches 18 to 20 per cent., and carries only 30 to 35 per cent. Cu with 6 oz. Ag and 0.1 oz. Au per ton.

There are three reverberatories, each 95 by 19 ft. Each furnace has two 520-hp. Erie City water-tube waste-heat boilers.

Matte from both the blast and reverberatory furnaces is brought by 60-ton ladles to seven basic-lined motor-driven 12-ft. converters. The siliceous ore for them is taken from suspended bins in 2-ton boats. Converter slag is skimmed in 6-ton ladles. Converter air is furnished as 12.5 lb. pressure by two Nordberg blowing engines of 12,000 cu. ft. per min. capacity, and five of half that capacity.

The furnaces are fettled with sulphide ores carrying 15 per cent. S, 23 per cent. SiO_2, 7 per cent. Cu, also flue dust, charged through the roof. Also some fettling is done by throwing quartz ore through the front. The tonnage smelted is 300 to 320 tons daily. The new furnace has 18 in. of magnesite brick at the slag-line near the front and so will, no doubt, not need fettling there. The charge carries 3 parts calcines, 1 of flue dust and 1 of fettling ores put in as above stated. The matte-fall is as much as 31 per cent. and the matte contains 36 per cent. Cu. With this is yielded a slag carrying 0.5 per cent. Cu. The furnaces are oil-fired, needing 0.9 bbl. of oil per ton of charge. The oil is heated by steam to 80° C. and blown in by air at 80 lb. pressure. California crude oil is used having a calorific power of 10,220 Cal. and weighing 8.05 lb. per gal.

The reverberatory gases pass to a chamber similar to the roaster dust-chamber. Little dust, however, is made.

The seven upright 12-ft. converters are charged by 80-cu. ft. (12-ton) ladles. The dished bottoms are 16 in. below the tuyères. In starting a converter, the first, or even the first two or three ladles added are blown without siliceous addition so that a magnetic coating is formed, and is followed by 1 ton of 74 per cent. silica ore and 6 tons of matte. In this size converter the slopping out a full speed may amount to 5 per cent. The converter slag will carry 1.5 Cu, but with the sweepings, etc., the whole will run to 5 per cent. Each converter needs two punchers and one-half skimmer, also a head skimmer for all.

The converter slag is now disposed of by pouring it on the ore-bed by a side-dump ladle, it being at the same time traversed so as to make a thin slag-layer 1 or 2 in. thick. The slag is thus layered with the ore, and the whole is removed by the steam shovel without difficulty. This method of slag disposal saves some $60 daily over the cost where it was solidified and then broken up for use at the blast furnace.[1]

The converter copper is moulded by two 21-ft. Walker casting machines, but a casting furnace for the storage and treatment of the copper is in contemplation. Each converter will produce 40 tons of converter copper daily of the composition 99.2 per cent. Cu and per ton 0.4 oz. Au, 28 oz. Ag. Some 11 to 12 million lb. are produced per month. In 1913 nearly 50,000 tons of siliceous ore was used in the converters.

Steam for power is obtained from the reverberatory waste-heat boilers supplemented at the power-house, by four or five 500-hp. oil-fired water-tube boilers having economizers. All the steam used is also superheated in separately lined Foster superheaters to 237° C. and reaches the engines at 210° C. The feed water is drawn from the condenser hotwell. The oil used is 1.125 lb. per i.hp.

Blast-furnace air at 28 oz. pressure is furnished by 11 Connersville

[1] A steam shovel can even re-claim from a solid dump of poured slag. At Anaconda the slag is moulded on a slag-casting machine and sent in blocks to the blast furnaces. L. S. A.

blowers, five of No. 9 size running at 78 to 90 r.p.m., and six of No. 10 size at 56 to 66 r.p.m. In reserve are two No. 7 blowers, electric driven.

Converter air at 12.5 to 13 lb. pressure is supplied by seven Nordberg compound engines, five to deliver 4000 to 6000 cu. ft. per min. each, two each of 12,000 ft. capacity.

Electric power for the works is generated by four 400-kw., 260-volt, direct-current generators supplying current to 14 electric locomotives, 7 electric cranes and 60 stationary motors.

The exhaust steam may be condensed to aid the engines, or otherwise sent to one of two 750-kw. mixed pressure turbo-generators, which produce a 2300-volt current. This is stepped up to 44,000 volts and sent to the El Tigre mine 67 miles distant in Sonora.

The average daily power used at these works is 4595 hp. and takes 13.65 lb. of steam per hp. About 6 per cent. of the power is used for the accessories of power generation. The cost per horsepower in 1913 was $54.84 per year.

An average of 1039 men was employed in 1913, equivalent to one man for 1149 tons, or of new material 999 tons per year.

Old Dominion Smeltery.[1]—A third blast furnace has been added and all the furnaces smelt ore high in fines. The flue dust and the flotation concentrates are briquetted before smelting, the table and vanner concentrates are mixed with plaster then made into briquettes. The ores come mostly from the Old Dominion and United Globe mines, though custom ores are also treated.

Central Chili Copper Co.'s Smeltery.[2]—This is a one-furnace plant at Panulcillo, Chili, 50 miles from the seaport of Coquimbo. Half the ore smelted is from the company mine, the rest is custom ores. This ore is brought down in 3-ton bottom-dump cars by two gravity incline tracks upon trestles, and is bedded into four long piles on the bedding floor 12 ft. below the trestles. Custom ores in 20-ton cars on the same trestles are distributed over the beds.

The furnace is 46 by 144 in. at the tuyères by 9 ft. high and is of 250 tons capacity on a blast pressure of 20 oz. The furnace settler 8 by 15 ft. builds up with iron sows, after running 30 to 40 days, when the furnace is shut down to change settlers.

There is produced a slag of 41 per cent. SiO_2 having 0.43 per cent. Cu and a 50 per cent. matte. The broken iron sows and the flue dust (after briquetting) are fed back to the furnace. The sows carry 40 per cent. Fe and 40 per cent. Cu.

The company employs 200 men on 12-hr. shifts paying from $0.45 to $0.81 per day.

[1] *Eng. Min. Jour.*, **100**, 1002.
[2] *Eng. Min. Jour.*, **100**, 787.

Smeltery of Union Minière du Haut Katanga.[1]—Two furnaces have been erected this year and two will go in in 1916, these four new furnaces each having a capacity one-third greater than the older ones. The completed seven-furnace plant will therefore have a capacity of 1000 metric tons daily, and an annual output of 40,000 tons of metal (and matte).

Of the total ore reserves (6,026,500 metric tons at Kambova, Luushia and the Star mines) it is estimated that 20 per cent. is direct-smelting ore of about 15 per cent. copper, while the remainder, called low-grade, carries 7 per cent. copper. One-fourth of the "low-grade" ore will be concentrated to give an 18 per cent. product, which, added to the direct-smelting ore, will give 1,600,000 tons of 15.5 per cent. smelting ore. To make up the total there remains 4,400,000 tons of 6 per cent. "low-grade" ore. The average of the reserve is 8.5 per cent. copper. Below water level at Kambova, preliminary borings indicate the existence of 3,000,000 tons of ore of the same grade as the superficial deposit.

The table herewith indicates what has been done in the 3 years 1912 to 1914 inclusive.

	1912.	1913.	1914.
Furnace days worked	171	443	671
Charges per furnace day (metric tons)	178	198	212
Total charge smelted (metric tons)	30,280	87,800	143,670
Total output (metric tons)	2,510	7,410	10,720
Average cost per ton of fuel	$46.44	$28.20	$21.48
Average cost per ton flux	3.72	2.20	2.14
Average cost per ton smeltery	$228.48	$148.44	$142.28

It is to be further noted that in 1911 there was an output 997 tons, for 1915 (estimated) 14,000 tons, for 1916, 25,000 tons, and for following years 40,000 tons per annum.

The Caucasus Copper Co.[2]—This is a British corporation, located in the Caucasus region at Dzanzul, distant 43 miles by road from Batum. The company gets its fuel-oil from Batum by pipe-line. It smelts concentrate. This, carrying 8.5 per cent. Cu, is roasted with the addition of 22 per cent. lime-rock in McDougall furnaces, then smelted in a modern, oil-fired furnace of the Anaconda type equipped with waste-heat boilers. The oil is atomized, using steam at 80 to 100 lb. pressure. The Baku oil (sp. gr. 0.875 and of 11,000 Cal.) used is 11 per cent. to 12.5 per cent. of the charge. A matte of 50 per cent. is yielded and the slag, retaining 0.4 per cent. Cu is granulated.

The matte, delivered to a two-stand converter plant, is treated in both basic- and acid-lined shells, ore being employed for lining in the latter case.

[1] *Eng. Min. Jour.*, **100**, 308; Mineral Industry, **23**, 240.
[2] *Eng. Min. Jour.*, **99**, 650.

The converter slag is returned to the reverberatory molten, and being basic, is a welcome addition.

The blister copper from the converter goes to two oil-fired refining furnaces, each of 10 tons capacity, and making two charges in 24 hr. About 14 per cent. of oil is used. The copper is hand-poured into 36-lb. ingots.

Kwarzchana Smeltery.[1]—The Siemens Kedabeg properties, already described in these volumes, are nearly exhausted. At Kwarzchana they are installing a carefully designed modern works having interesting features.

The mine ore of massive cupiferous pyrites with some covelite, carrying 5.9 per cent. Cu, is sent to the smelter by aerial ropeway. The screened-out fine ore is to be sintered with some flue dust in 10-ton pots, and the sintered product, together with the coarse ore, will be smelted pyritically in a rectangular blast furnace of 36 sq. ft. area at the tuyères by 18-ft. smelting column, jacketed in three tiers.

The matte is transferred by crane in a steel ladle to a barrel-type basic-lined converter of 5 tons capacity. The blister copper is taken molten from the converter to an oil-fired refining furnace. If the furnace can not take the copper it is moulded at the converter.

An arsenic plant will treat the flue dust rich in arsenic for its recovery as As_2O_3. The poor ore is to be leached.

The furnace, sintering pots and converter all send their gases to a large dust-chamber 166 ft. long, 40 ft. wide and 23 ft. high. From this two balloon flues each 120 ft. long (where the arsenic dust settles out) carry the gases to a stone flue that leads to a small stack. This flue is 2000 ft. long. The main part of the ore is smelted directly in two stages, as being on the whole the most profitable, due to the limited amount of converter air. The raw smelting takes place at the mines at Alla-Verdi in the hills; the matte converting and the refining is done at Manés at the railway station.

Societe Industrielle et Metallurgique de Caucase.[2]—At the mines, situated near Tiflis, the ore, carrying 30.1 per cent. Fe, 31.4 per cent. S, and 4.2 per cent. Cu, is pyritically smelted in round water-jacketed furnaces of 73 in. diam. at the tuyères with additions of siliceous limestone of 27 per cent. silica and some quartz rock of from 73 per cent. to 92 per cent. SiO_2. Russian coke, having 10 per cent. to 20 per cent. ash and a calorific power of 5900 to 6300 Cal., is used to the extent of 4.3 per cent. of the charge. The furnaces are of 160 to 180 tons capacity and yield a 20 per cent. matte and a slag 0.3 per cent. in copper. Part of this is returned to the furnace and tends to make it run more smoothly. The blast varies

[1] *Eng. Min. Jour.*, **99**, 652.
[2] *Eng. Min. Jour.*, **99**, 651.

from 25 to 34 oz. The slag is granulated, using eight times its weight of water, and is washed away in slag-lined launders.

The three concentration furnaces at Manés are of the circular water-jacketed type, 40 in. diam. at the tuyères, with a smelting column of 11 ft. They run smoothly on a charge of 100 parts of 20 per cent. matte, 15 parts limerock, 40 parts of quartz and 30 parts of converter slag using 6.5 per cent. of coke. On an air pressure of 37 oz. the tonnage output is 55 tons per day. There is yielded a matte of 45 per cent. Cu and a slag that retains 0.5 per cent. to 0.6 per cent. Cu. Flue dust from the blast furnace and converters is briquetted with lime and returned to the blast furnace.

The matte, carrying 45 per cent. Cu, is fed to small acid-lined barrel-type converters 72 in. diam. by 80 in. long and additional quartz is fed to the charge. The air pressure is 8.8 lb. and 280,000 cu. ft. is available per hr.

The blister copper is charged cold into one of the two oil-fired refining furnaces. These are built of quartz rock and have a quartz hearth while the roof is of magnesite bricks. The oil is atomized, using converter air, and to get better combustion additional air is blown in at the side-doors. Three charges are treated daily using of oil 10 per cent. of the charge.

About one-third of the copper is refined at Manés, using a current of 20 amp. per sq. ft., yielding a high-conductivity copper of 102.5.

The daily capacity of the plant may be given at 29,000 lb copper.

Basshi Smeltery.[1]—Is situated on Shishaka Island, Japan, the mines on the mainland adjoining. The ore is brought in 30-ton boats, hoisted in 1-ton cars to a delivery station 158 ft. above sea level.

In brief the ore is stall-roasted, smelted for a first matte, this matte roasted, concentrated in another blast furnace to a 70 per cent. matte, this treated in reverberatories to produce blister copper, which is refined in reverberatories.

There are for roasting 635 ore-roasting stalls and 126 matte stalls. These are of slag brick, 13 ft. long, 5½ ft. wide and 6 ft. deep, and hold each 35 tons of ore. Not only wood but 5 per cent. of coke is used in roasting. Roasting takes but 2 weeks to leave 10 to 12 per cent. sulphur in the ore.

Three 200-ton blast furnaces, one in reserve, smelt 380 to 400 tons daily, including a needed addition of 60 tons of siliceous copper ore. All this takes 15 per cent. of coke as might be expected. Sea-water is used for the jackets. The matte-fall is 15 per cent. of 27 to 30 per cent. matte.

[1] *Bull. Amer. Inst. Min. Eng.*, Nov., 1914.

This matte, after roasting, is concentrated in three circular blast furnaces to 70 per cent Cu. (white metal).

It is charged molten to six reverberatory furnaces where it is blown to blister of 98 to 99 per cent. Cu by means of air pipes on each side of the furnace, treating 3 tons of matte in 12 hr. and using 10 per cent. of fuel.

Refining is done in two 15-ton reverberatories. They use 32 per cent. of coal, 1.6 per cent. charcoal and about 6 per cent. of wood for poling. This fuel consumption seems high, but is similar to the experience in small furnaces in the copper country of Lake Superior.

Ikuno Smeltery.[1]—Pyritic smelting is performed, followed by bessemerizing in a Japanese forehearth. The cupola charge is of miscellaneous ore and concentrates,[2] containing 17 per cent. sulphur. Column-feeding is performed. That is, an inner annular pipe serves as a feed-tube. Into this is put the richer sulphides and the fuel the rest being fed outside the pipe, and being low in sulphur, does not stick to the walls. The pipe, 8 ft. long, reaches to within 6 ft. of the tuyères. The furnace yields a 40 per cent. matte. It goes for further treatment to the Mabuki hearth.

The Mabuki hearth consists of an excavation 9 ft. square, drained, provided with a 2-in. moisture escape pipe, and lined with gannister to furnish a circular cavity 3 ft. diam., into which slag is poured in order to dry it, and the slag as it gets solid is removed. A cover is built over of clay on a strong wire netting. The cavity is now charged with molten matte from the blast furnace, and charcoal put on top. It is blown by a single tuyère pointing downward at one edge. The slag formed is skimmed off every 15 min. There are three out of six of these hearths in constant operation each having a capacity of 3 tons of matte daily. About 6 per cent. of charcoal is used. A flue 200 ft. long connects these forehearths to the main flue. The flue dust contains 24 per cent. Cu; 40 oz. Ag and $4 Au per ton. There is yielded a black copper of 96 per cent. with Ag 266 oz. and Au 5 oz. per ton.

Ashio Smeltery, Houzan, Japan.[3]—The ore contains principally chalcopyrite with pyrite. The ore is classified into two grades: the first-class lump-ore sorted underground amounting to 214 tons daily, the second-class or concentrating ore amounting to 1263 tons per day.

The lump-ore is charged to the blast furnaces direct; the fines, including fine concentrates, are briquetted or sintered. If the latter, they are blast-roasted in eight 11-ton pots placed in two rows and used alternately.

[1] *Bull. Amer. Inst. Min. Eng.*, Nov., 1914.

[2] The concentrates are made by hand into briquettes 4 in. diam. by 5 in. high. The main dust flue to a stack on top of the hill adjoining is divided by a mid wall into two. One section is cut out and used for drying the briquettes while the other carries the draft, and so alternately. Drying is affected in 34 hr.

[3] *Bull. Amer. Inst. Min. Eng.*, Nov., 1914, 2670; *Eng. Min. Jour.*, **100**, 998.

Briquetting is performed in three briquetting machines giving an output of 40 tons per day.[1]

There are four blast furnaces, 42 by 160 in. with a height of 8 ft. 6 in. from tuyères to feed-floor, and of a capacity of 90 tons each per day. The forehearths, 12 ft. inside diam., are lined with magnesite bricks. Air is supplied at 32 oz. pressure. There is yielded a 40 per cent. matte and a slag containing SiO_2, 39 per cent.; Fe, 32.4; CaO, 19; Al_2O_3, 9.0 and Cu, 0.2 per cent.

The matte is treated in three electrically operated barrel converters, 72 in. diam. by 100 in. long, and produces 65,000 lb. of blister per day at 10 lb. pressure of blast. There are six shells, acid-lined with a decomposed laparite locally found. A new flue system was completed and put in operation in September, 1915. From each furnace a fan drives the gases through its own cyclone dust catcher to the furnace flue, thence by a rising flue to a dust-chamber of about 250 by 115 ft., having Rösing wires and a hoppered bottom for the convenient removal of the flue dust. The gases then pass to four stacks where they are diluted with fresh air blown into the stacks by fans.

The Kosaka Smeltery.[2]—This belongs to the Fujita Co., Japan. It is a large, well-operated plant, having many unique features. Much of the ore is high in heavy spar, and the slag carries 8 per cent. Zn., these two bases making smelting an unusually difficult problem.

The mine produces three classes of ore, black, pyritic and siliceous, respectively. These, upon screening to 0.5-mesh, are classified as coarse and fine. The latter size is briquetted by means of wooden stamps.

Properly combined, the ores make a self-fluxing blast-furnace charge as follows: Black ore, 4300 lb.; pyritic ore, 1000 lb.; siliceous ore, 2700 lb.; raw briquettes, 2700 lb.; slag from the second matte (concentration) smelting, 2000 lb., being in all 12,700 lb. of charge. The black ore averages 2.5 per cent. in copper, carries 13 per cent. Zn, and the gold and silver increase with the percentage of copper. The yellow pyritic ore will average 2 per cent. Cu, and is zinc-free. The siliceous ore carries 1.8 per cent. Cu, and is poor in gold and silver; it carries 10 per cent. sulphur.

There are six blast furnaces, one 60 ft. long by 43 in. wide, one 19 ft. long by 48 in. wide, four 25 ft. long by 48 in. wide. These are supplied with air at nearly 12 oz. pressure from eight electrically driven Root blowers requiring 400 hp. At this low pressure the 60-ft. furnace smelts in 24 hr. but 375 tons daily, while the five other furnaces output 875 tons of ore per day, or an average of 175 tons per furnace. The large furnace has an 11-ft. smelting column, the others 8 ft. At this low pressure there

[1] These briquettes have been treated by being fed to an endless-chain machine carrying small iron pots into which were delivered the briquettes, and these were coated by a stream of molten matte poured upon them as they passed along.
[2] *Bull. Amer. Inst. Min. Eng.*, Nov., 1914, 2679.

can be but little flue dust made. Compare this with American practice where 40 oz. is common. The Detroit Copper Mining Co. (Mineral Industry, **23**, 213) has a furnace operating at a pressure of 14 oz. only, for the confessed purpose of avoiding the formation of flue dust.

The matte-fall from the blast furnaces is 9 per cent. or 112.5 tons per day yielding a matte of 30 per cent. Cu and 16.5 per cent. of BaO, also a slag of 0.33 per cent. copper.

No coke or fuel is fed with the charge, but bituminous coal is introduced through the tuyères. Two men load cartridges on the end of an iron rod, push them into the furnace tuyères, and with a piston, inject charges of 2 to 3 lb. of coal into the smelting zone. Without these additions the furnace would not operate well.[1]

For the smelting and concentrating of the first matte, furnace No. 7 (26 ft. by 40 in.), situated in a separate building, is used. In this operation 40 per cent. siliceous ore and 1.5 per cent. coke is added, and 2.5 per cent. of bituminous coal is introduced at the tuyères. There is yielded a second matte of 50 per cent. Cu and a slag which goes back to the ore furnaces.

The 50 per cent. second matte is crushed and roasted to 4 per cent. sulphur in small Herreshoff furnaces, each of 5 tons daily capacity, giving 30 tons of roast daily. Cord wood is used in roasting to the extent of 10 per cent. of the charge.

For treating this second matte two reverberatories are employed, one 25 by 16 ft. and one 20 by 12 ft., outside dimensions. The idea is so to roast the matte that a small proportion of bottoms is made, which carry the gold, silver and impurities, and a high-grade matte (white metal) which is comparatively pure. The bottoms are cast into anodes for treatment at the electrolytic refinery.

The white metal goes to two blister furnaces, and the blister copper there produced is sent to two refining furnaces, the product of which is also sent to the electrolytic refinery.

To treat the slags and skimmings produced in the two reverberatories and blister furnaces a slag-smelting furnace is provided, this being 10 ft. high, 40 in. wide, and of a capacity of 65 tons. Its charge consists of slag, 100 lb.; scrap iron, 16 lb.; siliceous ore, 13 lbs. and coke 15 to 20 per cent. of the charge. There is yielded metallic lead, and a leady copper matte which is separated in a forehearth. This matte carries but 10 per cent. in lead and copper. There is produced 42 tons of lead bars monthly.

These bars are liquated in small reverberatory furnaces and the resultant lead is treated by the Parkes process to give a market lead and an enriched silver lead. The latter is treated in a small reverberatory, to-

[1] *Bull. Amer. Inst. Min. Eng.*, May, 1915, p. 1173.

gether with the slimes from the electrolytic refinery, and the resultant rich lead cupelled in an English cupelling furnace to yield doré bars.

The ore has an average of $7 in metals. The monthly production is given at $232,200 or on 37,000 tons smelted, $6.24 per ton. The total costs per ton of ore treated are $2.72 and the profit $3.52 per ton, certainly a very satisfactory showing. This estimate does not include depreciation nor selling costs.

Tsubaki Smeltery, Japan.[1]—The mine has a large body of silver ore which is smelted with purchased copper-bearing ores, the copper serving as a collector.

Reduction smelting is done in No. 1 furnace, which is 30 ft. long by 30 in. wide. The charge contains: (1) 75 tons of silver ore having 31 oz. Ag. per ton and high in heavy spar; (2) 34 tons of purple ore, the burnt pyrite from the acid works and carrying some copper; (3) 23 tons of limestone; (4) 23 tons of first matte returned to the furnace out of the 40 tons produced; (5) 3 tons of sulphide ores, making in all 158 tons, and finally 15 tons of coke, being 9 per cent. of the charge. The matte carries 20 per cent. Cu and 187 oz. Ag per ton. The slag has 0.2 per cent. Cu and 1.4 oz. Ag per ton. It will be seen that the addition of the burnt pyrite and the return of the first matte ensures the presence of sufficient copper to ensure the collection of the silver from the ore.

Pyritic smelting is done in No. 2 furnace, which is but 9 ft. long by 39 in. wide. Here the charge contains: (1) silver ore, 30 tons; (2) sulphide ores from outside mines carrying 4 per cent. copper and 45 per cent. sulphur; (3) zinc ores, 9 tons having Cu, 5.5 per cent.; Fe, 12 per cent., SiO_2, 6.6 per cent.; BaO, 9.2 per cent.; (4) scrap iron, 7.5 tons; (5) slag from the concentration furnace, 12 tons, or a total of 98.5 tons. Coke is used to the extent of 1.5 tons or 1.5 per cent. There is introduced through the tuyères 2.5 per cent. of bituminous coal. There is produced 10 tons of matte carrying 117 oz. Ag per ton and 18.5 per cent. Cu. The slag carries 1.8 oz. Ag per ton, 14 per cent. Ba, but only 0.12 per cent. Cu.

We come now to the concentration furnace where all the first matte is treated. The charge consists of (1) 20 tons of first matte from both the reduction and the pyritic smelting; (2) 4 tons of second matte returned to the furnace; (3) 5 tons of slags from the smelting hearths (later described); (4) 11 tons of silver ore; (5) 2 tons limestone, a total of 42 tons. There is added with this charge 0.5 tons of coke or 1.2 per cent. The furnace produces 10 tons of concentrated matte daily containing 503 oz. Ag per ton and 39 per cent. Cu.

On each side of the forehearth is a cavity lined with brasque and covered with a dome of fire-clay. Into the cavity is introduced 1000 lb. of

[1] *Bull. Amer. Inst. Min. Eng.*, Nov., 1914, p. 2692.

lead in bars and on this is tapped molten matte from the forehearth, then a sufficient addition of other bars. A wood log is placed upon the bath and pushed to the bottom by an iron bar put through a hole in the dome, thus thoroughly stirring or poling the bath, so that much of the silver in the matte is taken up by the lead. The bath is allowed to settle and the matte, containing 45 per cent. Fe and some lead, is removed and sent back to the furnace. To keep the bath fluid a few pieces of wood and charcoal are kept burning on top of it. The lead is skimmed, then ladled into moulds. These bars carry 570 oz. Ag per ton. This process of desilverization is an old German process, and in it the silver sulphide in the matte is decomposed, setting free the silver to be taken up by the lead.

Since this operation does not entirely desilverize the matte, it is repeated in a reverberatory furnace, 1 part of lead being then added to 3 parts of matte and the bath thoroughly poled. The matte is allowed to settle, and as it cools, the crust is lifted off, while the lead separates. The hotter the furnace during the mixing the better the desilverization. The matte is re-treated in the blast furnace.

The matte from the concentration furnace goes to the Mabuki hearths (see description of the Ikuno smeltery). At this works each hearth held 3 tons of 40 per cent. copper matte. Coke is used as fuel. To the molten bath is added 7 to 8 per cent. of litharge. There results a black copper still retaining one-third of the silver, while two-thirds goes into the reduced litharge. The treatment time is 30 hr.

For the black copper ingots four small brick Japanese liquation furnaces are used, 18 by 24 in. by 18 in. deep. Coke and charcoal are used for fuel. A blast at 3 oz. pressure is introduced at the top. A charge consists of 600 lb. of black copper, containing 4 to 5 per cent. Pb, 15 Ag, and 89 per cent. Cu. The charge is treated in an 8-hr. shift. Lead is here produced of 10 to 13 per cent. Ag, speiss containing 30 to 40 per cent. Ag and black copper.

Kano Smeltery, Japan.[1]—The ore is a mixed sulphide. Out of 150 tons daily, 40 tons is smelted direct, 110 tons is concentrated with a recovery of 63 per cent. only, and is briquetted and dried before reduction. The briquettes carry 2.5 per cent. Cu and the crude ore nearly that. The ore charge will average 12 per cent. zinc and some heavy spar, making reduction an unusually difficult operation.

Two blast furnaces 40 in. wide with six tuyères per side, and a smelting column of 7.5 ft., smelt a charge consisting of briquettes, 826 lb.; mine ore, 495 lb.; slag from the concentration furnace, 300 lb.; hearth slags, 82 lb.; scrap iron, 26 lb. Two per cent. of coke is also fed and 2 per cent. coal is blown in at the tuyères. Each furnace smelts daily a total charge

[1] *Bull. Amer. Inst. Min. Eng.*, Nov., 1913, 2684.

of 92 tons with a low blast pressure of 8 oz. and with a matte-fall of 10 per cent. There is yielded a matte of 20 per cent. Cu and 10 per cent. Zn.

The slag from the forehearth, containing 8 per cent. zinc, but only 0.39 per cent. Cu, is granulated and run to waste.

The first matte is sent to the concentration furnace, this being a round blast furnace 40 in. diam. The charge of this furnace consists of the above-mentioned zincky matte, 500 lb.; siliceous ore, 235 lb.; middlings from the concentrates, 85 lb. This latter carries 15 per cent. zinc. For fuel 2.8 per cent. coke and 8.8 per cent. coal is used.

Eight tons of matte is produced, with 43 per cent. Cu and about 7 per cent. zinc. The slag has only 0.54 per cent. Cu and carries also Fe, 34.5 per cent.; SiO_2, 31.3; Zn, 8.7; Al_2O_3, 6.6 per cent. The 43 per cent. matte is poured into a Mabuki hearth (see description of Ikuno Smeltery). It takes 4 hr. to roast the matte and 30 hr. to finish the charge, using 14 per cent. charcoal and about 2 per cent. coke. The production is 2000 lb. of black copper (see charge).

The assay value of the mine ore is $6 per ton. The loss in concentrating and smelting is $1.96 per ton or 32 per cent. The property is being equipped for a production of 200 tons daily and it is estimated that the total cost will then be $240 per day.

Copper and Its Alloys

Copper at High Temperatures.[1]—An oxidizing atmosphere at high temperature gives a high degree of ductility. In a neutral atmosphere unannealed copper up to 1000° C. is stronger than annealed. At 700 to 750° C. fracture occurs through all the crystals; outside this the fracture is between the crystals. A range of low ductility has been found between 250° and 450° C. Results of tensile tests are consistent with the theory that the crystals of copper are enveloped in a cement at low temperature, stronger than the crystals themselves.

Turbadium Bronze.[2]—This alloy has a tensile strength of 35 to 42 tons per sq. in., an elongation of 14 to 20 per cent. in 2 in., and is not appreciably corroded by sea-water. Its composition is Cu, 48 per cent.; Zn, 46.45; Sn, 0.5; Pb, 0.1; Fe, 1.0; Al, 0.2; Mn, 1.75; Ni, 2.0 per cent. Thus it is a bronze having nearly 2 per cent. of manganese and nickel respectively and containing certain metallic impurities.

Construction and Operating Costs

Relative Costs in Blast-furnace and Reverberatory Treatment.[3]—With grate-firing of the reverberatory furnaces at Anaconda it was estimated

[1] *Proc. Inst. of Metals; Min. Eng. World,* **42,** 466.
[2] *Chem. News.*
[3] *Bull. Amer. Inst. Min. Eng.,* May, 1915.

that the cost of briquetting and blast-furnace expense was equal to the combined roasting and reverberatory cost, but on the introduction of coal-firing, 50 cts. per ton was cut off, due to fuel economy. Taking the figures of reverberatory performance at other plants, we may say that reverberatory cost, computed at $1.15, would be reduced to $0.65 per ton.

Due to the cheaper reverberatory costs, and the advantage that type of furnace has in treating fine material, the new way will be to simplify concentration methods, recover the present metal values more closely by flotation, roast the concentrates, and smelt these in reverberatory furnaces, doing away with the blast furnaces. To handle the by-products which formerly went to the blast furnace, a large reverberatory has been put in, at which will be treated all the molten converter slag, converter by-products and siliceous flotation concentrates. These latter will carry enough sulphur to clean the copper out of converter slag, and enough silica to bring the furnace slag to the normal silica contents. Even if such slag still carries 0.6 per cent. copper it will be better than treating in the blast furnace, but no such loss is anticipated.

British Columbia Smelting Co.—(A) When operating two 51-in. by 40-ft. blast furnaces, the following are the operating costs for smelting and converting:

Costs.	Total Quantity used.	For Furnaces.	For Converters.
Clay	$6.45	0.60	$5.85
Wages	326.90	269.20	57.70
Supplies	85.35	82.05	3.30
Wood			
Coke, 206.5 tons @ $6.09	1257.85	1257.85	......
Power	77.50	63.95	13.55
Blacksmith coal	0.70	0.50	0.20
Flux	164.30	164.30	......
	$1932.20	$1842.95	$89.25

Ore treated, tons	1,695.16
Blister Cu produced, pounds	22,009.40
Cost per ton ore to produce matte	$1.084
Cost per pound Cu for converting	0.00391
Coke, used daily, tons	206.5
Coke used, per cent	12.18
Men employed	
Foremen	6
Men	95
	101

or 542 tons per man per month.

(B) When operating three furnaces, two 51-in. by 30-ft., and one 51-in. by 20-ft., the following were the operating costs:

Costs.	Furnaces.	Converters.	Total Quantity Used.
Wages	$333.63	$73.53	$407.16
Supplies	66.72	18.38	85.10
Wood	1.50	13.60	15.10
Clay	0.55	5.33	5.88
Coke 315.8 tons @ $6	1892.79	......	1892.79
Power	73.40	14.97	88.37
Blacksmith coal	0.63	0.13	0.76
Flux	253.56	......	253.56
Total	$2622.78	$125.94	$2748.72

Ore treated, tons		2,224.2
Blister Cu, pounds		26,260.0
Coke used, per cent		13.7
Foremen.. 5	Average men per day	125.0
Men...... 125	Tons smelted per man per day	17.8
130	Tons smelted per man per month	551.6

(C) Total costs. The following costs do not include overhead expense, depreciation and insurance. The costs per ton of ore smelted to matte are:

For coke	0.851
For flux	0.114
For labot	0.150
For power	0.033
For supplies	0.030
	$1.178

The cost per ton of copper of converting matte to blister copper is $4.40, or per pound of copper, $0.0022, computed on a basis of 22 lb. copper per ton of ore; this equals $0.048 per ton of ore, or for smelting and converting of $1.228 per ton of ore. The cost of coke delivered into the main bins is $6, of flux $2.75. The cost of power per kilowatt-hour is $0.0065. The furnaces were slowed up with an excess silica on the charge because of shortage of ore, hence the higher cost per ton of ore smelted to matte. They only smelted 6.55 tons per sq. ft. of hearth area against 6.66 tons per sq. ft. when the cost of smelting was $1.084; see (A).

DISTRIBUTION OF SMELTER PAYROLL FOR SAME MONTHS, AND COST OF LABOR PER TON OF ORE SMELTED

	Payroll Distribution.	Cost of Labor per Ton of Ore Smelted.
Sample mill	$318.05	$0.00463
Bins	729.35	0.01060
Briquetting	376.65	0.00546
Furnaces	6508.25	0.0958
Slag disposal	1413.65	0.0206
Linings	615.60	0.0078
Converters	1016.95	0.0147
Crane	277.25	0.00403
Water system	224.65	0.00326
General surface	430.15	0.00624
Power-house	585.60	0.00850
Total	$12,496.15	$0.18161

The briquet mill handled 1057 cars of blast-furnace flue dust, and made 398 tons of briquets. Briquets cost $0.045 per ton for labor.

Smeltery Brick-laying Costs.—The following interesting figures on the cost of laying brick were obtained from a large amount of construction work at a Salt Lake Valley smeltery:

Buildings. Based on bag-house construction:

Cost of brick per 1000	$5.75
Cost of lime per 1000 brick @ 18 cts. per bu	0.335
Cost of sand per 1000 brick @ 65 cts. per yd	0.193
Wages of masons per 1000 brick @ $5 per day	3.205
Wages of helpers per 1000 brick @ $1.75 and $2.25	1.530
Total cost per 1000 brick	$11.013

Average brick laid per 8-hr. day per mason, 1560.2
Average number of helpers per mason, 1.285.

Foundations. Based on H. & H. pot foundations:

Cost of brick per 1000	$5.75
Cost of cement per 1000 brick @ 81.64 cts. per sack	6.625
Cost of sand per 1000 brick @ 65 cts. per yd	0.495
Wages of masons per 1000 bricks @ $5 per day	5.164
Wages of helpers per 1000 brick @ $1.75 and $2.25	3.184
Total cost per 1000 brick	$21.218

Average brick laid per 8-hr. day per mason, 968.3.
Average number helpers per mason, 1.877.

Flue construction, over forms. Based on section of Fogh catenary flue 21-ft. base:

Cost of brick per 1000	$5.75
Cost of lime per 1000 brick @ 18 cts. per bu	0.35
Cost of sand per 1000 brick @ 65 cts. per yd	0.21
Wages of masons per 1000 @ $5 per day	7.353
Wages of helpers per 1000 @ $1.75 and $2.25	6.327
Total cost per 1000 bricks	$19.99

The above includes bricklaying, tending and materials only. It does not cover freight, unloading, forms, etc.

Hydrometallurgy of Copper in 1915

By L. S. Austin

Mr. Lawrence Addicks[1] has summed up the present aspects of the leaching of copper ores briefly as follows:

"Three essentially different problems should be distinguished: First, for sulphide ores, roasting and leaching is now not very promising on account of the tremendous quite recent developments in flotation. Second, for oxide ores, where conditions are favorable, leaching has come to stay. Third, mixed sulphides and oxides represent an entirely open problem, and it is impossible to say which process will fit. The presence of silver and gold complicate the problem. As to precipitation, there is now an increasing trend toward electrolysis. Scrap iron as precipitant is practically impossible because there is not enough scrap iron available."

[1] *Met. Chem. Eng.*, **13**, 324.

Acheson graphite electrodes (heretofore thought to be unsuitable in sulphate solutions) are now successfully used for anodes; iron oxide and alumina, heretofore thought of as detrimental bases, are now turned to advantage in the electrolytic cell, the iron being a depolarizer and the increasing aluminium sulphate in the electrolyte forming a natural diaphragm which prevents action of the ferric sulphate on the copper cathodes. In fact it has been found possible to get along very well with foul solutions.

The increasing adaptation of flotation to the treatment of low-grade copper ores has rather discouraged the use of leaching methods, and these processes have not made the progress expected. The field is still open for oxidized ore where flotation has not thus far been successful.

Electrolysis of Copper Sulphate Liquors.[1]—In a paper read by Lawrence Addicks at the San Francisco meeting of the American Electrochemical Society, Sept. 17, 1915, he gives the results of research, conducted at Douglas, Ariz., on the conditions of electrolytic recovery from leaching solutions, using carbon anodes.

To quickly take up the oxygen released at the anode with the ferrous sulphate in the liquor, this must be strongly agitated with compressed air. At the cathode, however, a low rate of circulation suffices with the liquor reasonably rich in copper sulphate, this latter condition preventing liberation of hydrogen or precipitation of impurities.

Experiments on varying quantities of free acid, iron and alumina, and temperature of the electrolyte, showed that:

1. A temperature of 115° F. (56° C.) was the best.
2. The acid should be in the vicinity of 4 per cent.
3. The alumina should be between 3 per cent. and 4 per cent.
4. With adequate agitation no ill affect is produced by high iron.
5. The effect of sulphur dioxide as a depolarizer was tried, but the small amount of this gas that can be taken up by the sulphate liquors afforded but little advantage in this respect.
6. At the anode the oxidation of the ferrous sulphate depolarizer yields ferric sulphate according to the reaction,

$$Cu + Fe_2(SO_4)_3 = CuSO_4 + 2FeSO_4,$$

and this ferric sulphate has a corrosive action at the cathode. Thus at 123° F. and at 13 amp. per sq. ft., a 0.75 per cent. ferric iron solution would corrode the cathode as fast as the current would deposit upon it, but it was found in presence of aluminium sulphate in the liquor this corrosion could be largely overcome.

Another difficulty was to obtain a bright deposit on the cathode due

[1] *Met. Chem. Eng.*, **13**, 728; *Trans. Amer. Electrochem. Soc.*, **28**, 73.

to the fact that cupric sulphide and cuprous chloride tended to deposit there. It was found that a brilliant deposit was possible when the electrolyte was free from chlorides and sulphur dioxide, and when previous reduction of ferric sulphate had been properly carried out.

For reducing ferric sulphate to ferrous form three reducing agents are readily available, viz., sulphur dioxide, cement copper and the calcines.

Sulphur dioxide when used for the purpose acts upon the liquor in a coke-filled tower. For each unit of copper about 0.5 unit of sulphur as SO_2 will be needed, and from this in the tower reactions 1.5 per cent. of free sulphuric acid will be produced. Now the liquors, after the tower treatment, take up no more than 0.15 to 0.20 per cent. of SO_2. This acts so slowly that it takes a high temperature (160° F.) or a period of rest of 16 hr. to restore the original blue to the liquor. Since this appears to be impracticable, the only way seems to be to circulate the solution actively through the cells so that 0.1 per cent. of the iron is oxidized in transit, and this small amount the SO_2 can readily reduce.

After the liquor leaves the tower it is passed through granulated cement-copper. This reduces the remaining traces of ferric iron and precipitates any chlorides such as cupric chloride.

Calcines are a fairly effective reducing agent for ferric sulphate, and when the liquor from the electrolytic cells goes to them, at least half its ferric sulphate content is reduced to ferrous form.

Six factors influence the rate of corrosion at the cathode: (1) the concentration of ferric sulphate in the electrolyte; (2) the temperature of the electrolyte; (3) the concentration of the aluminium sulphate in the electrolyte; (4) agitation; (5) the surface exposed to corrosion; and (6) the current density.

It is finally concluded as the result of the research that: (*a*) carbon anodes will stand up in sulphate liquors if properly depolarized; (*b*) aluminium sulphate can be used as a substitute for a diaphragm; (*c*) 2.25 lb. of copper per kw.-hr. can be recovered under proper operating conditions; (*d*) great quantities of various sulphates, present as impurities do not foul the cathodes; (*e*) three or possibly 3.25 units of acid are made per unit of copper (when using SO_2) of which 1.5 to 1.75 units are new acid from the tower gases.

No mechanical difficulties are experienced in the tower, but a thorough study remains to be made of the chemistry of reduction of ferric sulphate by sulphur dioxide, in order to utilize the roaster gas and to heat to advantage.

Mr. Addicks in U. S. Patent 1138921 of May 11, 1915, gives a practical illustration of good work under his process as follows:

A solution containing 3 per cent. copper, 3 per cent. ferrous iron, 3 per cent. of alumina and some free sulphuric acid to prevent formation of basic salts, is electrolized with a current density of 13.5 amp. per sq. ft. at 115° F. and with a circulation sufficient to keep the ferric iron at 0.25 per cent. Under these conditions a cathode deposit equivalent to 70 per cent. to 90 per cent. of the theoretical can be obtained

Anodes Suited for Copper Sulphate Solution.[1]—Lawrence Addicks discusses the merits of the three kinds of anodes that can be practically used, viz., lead, magnetite and carbon.

There are two objections to lead anodes, one being that they do not work well at low voltages and second that due to the flaking off of the sulphate and peroxide formed on their surfaces their life is short.

Magnetite is fragile and expensive, and it remains to be seen whether it is suited to large-scale work, as at Chuquicamata for example.

Any disintegration of the carbon anode must be due not to any physical attack, but to chemical transformation of the oxygen released at the anode into something resembling ozone. However, after ferrous sulphate was adopted as a depolarizer to the extent of 1.5 per cent. and the solution kept in agitation, no deterioration was shown even with several months use. Both Acheson graphite slabs and baked carbon slabs have given satisfactory service. The Acheson slabs are trued up, electroplated with a thin film of copper on the upper end and bolted to the copper contact slips. When carbon is used as an anode, being the electronegative substance, there is on open circuit a back electromotive force of 0.29 volt.

Leaching Flue Dust and *Carbonate Ore.*[2]—G. B. Wootey describes an inexpensive and efficient method of treating 25 tons daily of flue dust and copper carbonates.

A stream of water from the nozzle of a 2½-in. hose at 60 lb. pressure washed the flue dust into a 9 by 9-in. launder 400 ft. long to settling tanks 28 ft. diam. by 12 ft. deep, the operation taking 3 hr. After settling over night, the supernatant acid solution of the tanks was pumped on a bed of carbonate ore, and percolated through the ore pile to an asphalt floor beneath. The sloping ore-bed, 80 by 70 ft., was piled with 1500 tons of ore, unloaded upon it from a railroad track adjoining and spread by means of a steam crane, leaving a flat top. The bed was surrounded by low walls, thus forming a basin for the acid liquor. Drainage from the pile was to a small sump, then to a launder 3 by 3 ft. by 300 ft. long, having cross-partitions and filled with scrap iron.

The ore was leached in 5 or 6 weeks. It was removed in part by the crane, in part by sluicing.

From 248 tons of flue dust and 250 tons of carbonate ore the recovery

[1] *Trans. Amer. Electrochem. Soc.*, **28**, 73; *Met. Chem. Eng.*, **13**, 749.
[2] *Met. Chem. Eng.*, **13**, 295.

was 94.4 per cent. of the copper at a cost of 7.5 cts. per lb., including amortization of plant. This latter was estimated to cost $1000 to $1200.

Factors Influencing Extraction in Leaching Copper Ores.[1]—Stuart Croasdale gives the conclusions drawn from large-scale leaching.

1. Colloidal slime retains mechanically as much copper solution as is retained by the coarse material.

2. In treating different grades of similar ore the value of the tailings is a constant, so that in case of two ores of 2 per cent. and 1 per cent. respectively, the percentage recovery in the lower grade is much less.

3. Ores, abundantly washed, show no farther recovery of soluble copper in the tailing.

4. It is better to begin leaching on dry ore rather than upon ore first saturated with water.

Benedict Leaching Process.[2]—In Mineral Industry, **23**, 262, the principles of this process are discussed.

Referring to the flow-sheet, Fig. 1, leaching is carried out as follows:

A tank 54 ft. diam. by 12 ft. high is filled to the depth of 10 ft. with 1000 tons of dump material which has been freed from slime by a Dorr classifier.

Upon this is run 500 tons of first leaching solution containing Cu, 0.5 per cent.; NH_3, 1.0; CO_2, 0.8 per cent. The first of this solution displaces the water of the sands, and as soon as the ammonia begins to show itself at the outflow, it is sent to the new second leaching solution vat, to the extent of 200 tons. The rest of the outflow, 300 tons, is delivered to a rich solution tank which now contains Cu, 0.833 per cent.; NH_3, 1.0 per cent.; CO_2, 0.8 per cent. From the vat containing the second leaching solution comes 500 tons, and this goes to the new first leaching solution vat. Next comes 250 tons of first wash which passes to the new second leaching solution vat there joining the first portion of the first leaching solution. Finally comes a water-wash.

The rich solution (300 tons) is subjected to distillation in a distilling apparatus yielding a distillate of ammonia and ammonium carbonate, and a precipitate of copper oxide containing 79 per cent. Cu. From this precipitate is decanted 325 tons of barren solution, that carries Cu, 0.008 per cent.; NH_3, 0.01 per cent.; CO_2, 0.01 per cent. This may be run to waste, or used in place of fresh water at the final wash. The precipitate of about 6650 lb., after filtering, is sent to the smelter. The distillate (about 25 tons) is added to the new second leaching solution, and the shortage of ammonia and ammonium carbonate made up by a further addition of fresh chemicals.

[1] Paper read before Utah Section Amer. Inst. Min. Eng., *Eng. Min. Jour.*, **99**, 576.
[2] U. S. Patent 1131986, Mar. 16, 1915; *Met. Chem. Eng.*, **13**, 448; *Min. Mag.*, **12**, 101.

The process is being carried out on mill tailings at the Calumet & Hecla property, where a mill of 4000 tons daily capacity is to be erected.

Experiments made in Arizona in 1892 upon tailings containing 3.6 per cent. to 5.0 per cent. copper showed that the extraction by ammonia was rapid, and in 2 hr. 65 per cent. of the copper was dissolved. An addition of ammonia sulphate to the solution increased solubility to over 70 per

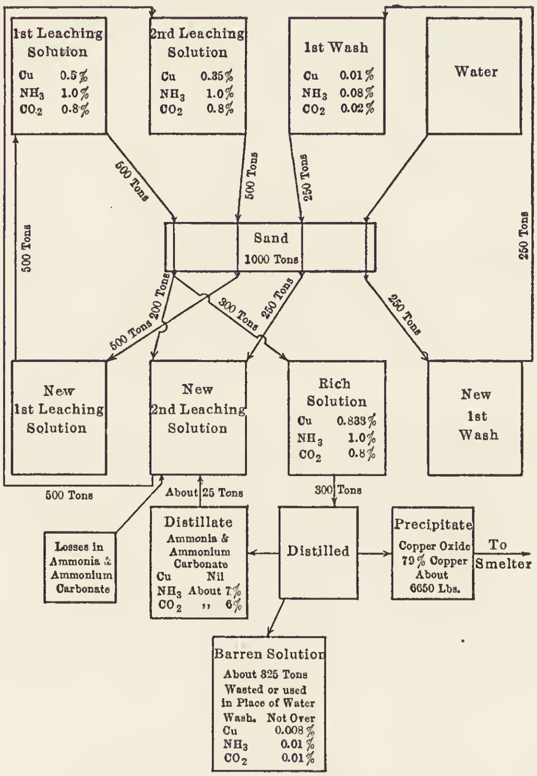


Fig. 1.—Ammonia leaching process

cent. The subsequent recovery of the ammonia by distillation was 96 per cent., and this 4 per cent. loss was considered to be so great that the process was given up.

Experiments on the steel intended for the tanks showed some corrosion when soluble sulphates are present in the ammoniacal-copper solution.

Weidlein's Process.[1]—A somewhat incoherent description is given by the writer of the article. The ore is divided into sands and slimes, the first percolated, the slimes extracted in Dorr settlers by the counter-cur-

[1] *Met. Chem. Eng.*, **13**, 652.

rent system. The solution is neutralized with lime, saturated with SO_2 gas and heated to 160° F. under a pressure of 100 lb. per sq. in., when the copper falls out in pure form. The sulphur dioxide is concentrated from the weaker smelter fume by selective absorption. The details of the method are unavailable for publication.

The Smith Leaching Process.[1]—E. A. Cappelen Smith has patented a method of treating sulphide copper ores containing chalcopyrite and chalcocite by roasting, leaching and electrolysis.

The ore, as a concentrate, is roasted in a seven-deck Wedge or Herreshoff furnace at a temperature between 600° C. and 750° C. in the upper five hearths, and at 450° C. to 500° C. in the lower two hearths. In the hotter hearths the sulphur is eliminated and FeO is formed; in the lower hearths the FeO is converted into Fe_2O_3. The copper compounds are oxidized; the iron is in a form insoluble in sulphuric acid. It is intended that the sulphur escaping shall be used for making sulphuric acid to be utilized in this process.

When regularly operating, a quantity of partly leached ore (from which 85 per cent. of the copper has been removed by a neutralizing leaching to be later described) is treated by agitation with the final solution from the electrolytic vats, this solution containing 10 to 12 per cent. of free sulphuric acid and 2.5 per cent. copper. This removes the copper and a little ferric iron from the ore. The solution goes to another agitating tank, where, to remove the ferric iron, some fresh calcine is added in quantity sufficient to neutralize the excess acid. This is called the neutralizing leaching. The ferric iron falls down as a basic sulphate while 85 per cent. of the copper in the calcine is dissolved. Both solution and ore are withdrawn to a settling tank, where the calcine and basic iron quickly settle out and the solution is promptly decanted, filtered and sent to the electrolytic cells.

In the electrolytic cells the anode is of antimonial lead, the cathode of copper. In roasting, less than 1 per cent. of ferrous iron still remains unchanged. This ferrous iron in the leaching operation is dissolved as such, and during electrolysis this is converted to ferric form. It is at this stage that the electrolyte should be withdrawn for use in leaching. Should electrolysis, however, be carried further until the copper-content of the solution gets low, the iron will be re-converted to ferrous sulphate, and this is not removable like ferric sulphate.

Bacon's Precipitation Process.[2]—A copper-bearing sulphate or chloride solution is treated by means of hydrogen sulphide with precipitation of cupric sulphide and regeneration of the solvent. To the precipitate is added elemental sulphur in quantity equal to one-half the sulphur in

[1] U. S. Patent 1134767, Apr. 6, 1915; *Met. Chem. Eng.*, **13**, 451.
[2] U. S. Patent 1151234, Aug. 24, 1915; *Met. Chem. Eng.*, **13**,872. *Eng. Min. Jour.*, **100**, 640.

the sulphide, and the mixture, with addition of a hydrocarbon, is distilled at a temperature of 300 to 360° C., whereupon hydrogen sulphide is generated. Cuprous sulphide is formed and this can be treated in a copper converter.

Hybinette Process.[1]—N. V. Hybinette, Christinia, Norway, states that solutions containing 1.5 per cent. ferric oxide readily dissolve copper sulphides, while they are insoluble in solutions containing less than 1 per cent. When the solution contains 1.5 to 2 per cent. of ferric oxide it still does not interfere seriously when the solution is being treated electrolytically. His process is as follows: To the ore is added 2 to 5 per cent. of sodium sulphate which forms a double sulphate of sodium and copper, decomposed only at a high furnace temperature. This fusible double sulphate dissolves sulphides and forms a spongy mass, easily leached by sulphuric acid. The solution from the subsequent electrolytic treatment contains sulphuric acid, ferric sulphate and accumulating sodium sulphate. When the solution gets to have 45 per cent. $NaSO_4$ it is added to the ore rather than the solid salt. Whatever iron salt is also present has a solvent effect on the undecomposed copper sulphide.

Van Arsdale Process.[2]—To reduce polarization sulphur dioxide has heretofore been vainly used to saturate copper sulphate leaching solutions before electrolyzing. The trouble is that the electrolytic hydrogen evolved at the cathode, reacting with the sulphur dioxide, forms hydrogen sulphide, which then precipitates copper as sulphide. In his patent, Van Arsdale claims that such deposition can be prevented, and his process is as follows:

The ore is given a sulphating roast to have at least 2 parts of sulphur for each part of copper. In regular operation the calcine is treated by the acidulated mother-liquor, washed with a weaker solution, finally with water, giving a solution from which copper is precipitated by means of iron, and the spent solution wasted. The first wash or rich solution is treated electrolytically, using sulphur dioxide to prevent polarization by combination with oxygen at the anode and to reduce ferric salts to ferrous form. The warm gas is bubbled through the electrolyte in the cells. Hydrogen, evolved at the cathode, combines with the SO_2 forming H_2S which reacts to form copper sulphide, this tending to deposit on the cathode. To avoid this only 80 per cent. of the copper in the solution is precipitated. With a 10 per cent. solution of copper sulphate, containing enough sulphur dioxide to prevent polarization and reduce ferric to ferrous salts, 10 amp. per sq. ft. at 0.7 to 1.2 volts, is sufficient to affect precipitation of 80 per cent. of the copper without throwing out sulphides.

In his U. S. Patent 1119478 he gives a process thus described: The

[1] U. S. Patent 1140182, May 25, 1915; *Eng. Min. Jour.*, **100**, 602.
[2] U. S. Patent 1119477, Dec. 1, 1914; *Eng. Min. Jour.*, **100**, 61.

ground ore is given a sulphatizing roast, if necessary with the addition of pyrite. It is then leached with the acid solution from the electrolytic vats, and part of the filtrate is again run through the ore to yield a strong solution. The succeeding weaker washes are run over scrap iron to recover any remaining copper, and the liquor run to waste, thus avoiding the building up of the leaching solution in impurities. Meanwhile the strong solution, after treatment with SO_2, goes to the electrolytic vats. There may be added sufficient of the gas to satisfy the equation, $CuSO_4 + SO_2 + 2H_2O = Cu + 2H_2SO_4$, but at any rate enough to reduce the ferric salts to ferrous form. By operating in this manner a lower voltage is needed than in ordinary electrolysis.

Lawrence Addicks objects to the use of sulphur dioxide directly introduced to the cells because the gas in excess escaping into the tank room makes the atmosphere unbearable, it escapes so freely from warm solution in active motion that a great excess would be needed, and the liquor is slow in taking up the gas.

Leaching of Tailings Dumps.[1]—At the Wallaroo & Moonta mines, South Australia, are five tailings heaps aggregating 1,500,000 tons, and containing originally 0.9 per cent. copper; also slime deposits of 323,000 tons. The heaps vary from 30 to 60 ft. high and cover an area of 60 acres. These heaps, by long exposure, have become oxidized. The top of a heap is divided by little ridges into 12-ft. squares to control the distribution of the water brought upon them. The leaching liquor contains 0.16 per cent. iron sulphate and a little free sulphuric acid. It is pumped on the heap at the rate of 20,000 to 40,000 gal. per hr. To supplement the mine-water there is a pumping station at Moonta Bay to supply sea-water. From the heaps the solutions drain to six wood-lined masonry tanks, 60 by 30 by 3½ ft. deep. The first two tanks are for settling the liquors, the remaining four are charged with scrap iron. From the final tank the solutions flow through 3000 ft. of wood-lined launders, 2 ft. 8 in. wide by 9 ft. deep, also containing scrap iron, so that the copper is thoroughly precipitated from the solution, and this solution is returned to the heaps.

The slime deposits are thus treated: They are run out on flat places and dried, and plowed to expose fresh surfaces to oxidation. Next the slimes are loaded into cars, and at the treatment plant, passed through agitators using, per ton of slimes, 1200 to 1400 gal. of the spent leaching liquors, with addition of 0.12 per cent. sulphuric acid. The agitated pulp is sent by launder to settling dams. The slimes settle and the supernatant solution, passing through clarifying reservoirs, goes to the scrap-iron tanks of the leaching system.

[1] *Eng. Min. Jour.*, **99**, 438.

In 1912 there was recovered 9400 tons of precipitate, which contained 76 per cent. copper.

Copper Queen Precipitating Plant.[1]—We have described in MINERAL INDUSTRY, **21,** 256, the original plant of the company. The new one incorporates improvements, the result of the early experience.

The upper levels of the Holbrook mine were worked out years ago, then gobbed with rich waste. These old workings were drifted and crosscut,

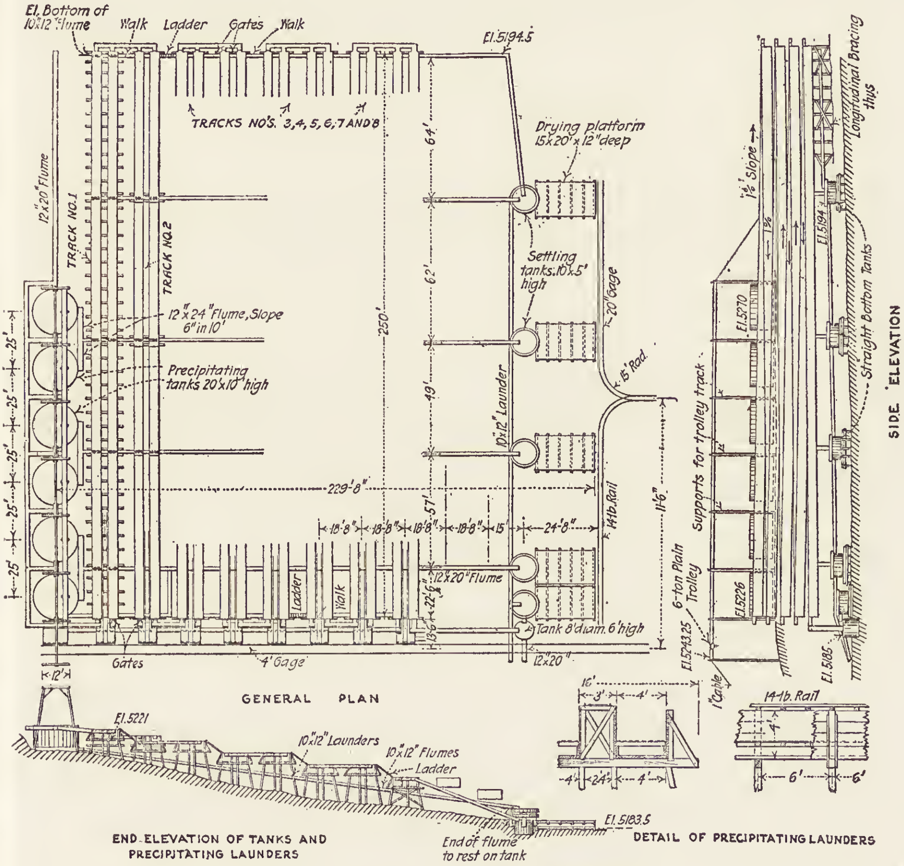


FIG. 2.—Copper Queen precipitating plant.

and pipes were put in to distribute through them the barren solution from the precipitating plant. Water is also pumped through burning sulphide stopes to extract the contained copper.

The new precipitating plant is placed upon a 20 per cent. slope, covering 2.6 acres. The conduit, 3600 ft. long, leading from the mine to the

[1] *Eng. Min. Jour.*, **99**, 17.

plant is 10 by 24 in. in section, and for the last 560 ft. is a 14-in. redwood pipe, making an inverted syphon to carry the water under the railroad track. The details of the plant are shown in Fig. 2.

The first unit of the plant is six redwood tanks, 20 ft. diam. by 10 ft. deep, having false bottoms, and with a fall of 0.4 per cent. between tanks. They are designed to receive the heavy scrap iron. Any tank may be by-passed and the cement copper beneath its false bottom flushed out through doors near the bottom, then by launder to the settling tanks.

The second unit consists of eight double parallel flumes with small connecting launders at the ends of the flumes, the solution flowing through them in series. Each flume is 250 ft. long, 4 ft. wide, 45 in. deep with a 1 per cent. slope. It is divided by transverse partitions into five spaces, and has a false bottom upon which the smaller scrap iron is laid. Stoppered holes at the end of each compartment allow the cement copper, collecting under the false bottom, to be flushed as desired into the 10 by 12-in. transverse collecting launders below, and these convey it to the 10 by 5-ft. settling tanks. Either one of the double flumes may be by-passed when the other is being cleaned out.

The third unit consists of the five settling tanks already mentioned, where the precipitate settles, and the clear water decanted. A watertight door at the side of the tank is then opened and the precipitate shoveled out upon the drying platform 15 by 20 ft. in area, with sides 12 in. high. After several days drying the material is shoveled into mine-cars and transferred to railroad cars to go to the smelter.

The barren solution from the last double flume flows to a final settling tank, whence it is pumped back to the mine through an 8-in. wood-lined pipe.

Transversely to the double flumes at one end is a track with a transfer car which takes up and down the grade a mine-car filled with scrap iron. At each double flume is a tram track, so that when the transfer car is raised to its level, the mine-car can be trammed along the flume, and there deposits its load as needed. Heavy scrap intended for the tanks is placed on the transfer car and raised to the top of the grade. Here it is picked up by a 6-ton traveling triplex chain-block carried on an overhead track, and distributed to the tanks.

The mine water to the plant contains 0.296 per cent. of copper as sulphate, also ferric and ferrous sulphates. The barren solution leaving the plant contains Cu, 0.10 per cent.; ferric iron, 0.10; free acid, 0.140 per cent., indicating an extraction of 97.66 per cent.

The precipitate of the old plant contained 35 per cent. H_2O and the dried sample carried 39 per cent. Cu. Theoretically 1.23 lb. iron is used for precipitation, or of scrap iron of 85 per cent. Fe, 1.45 lb. per lb. of copper.

The approximate cost of the plant was $35,000, using 350,000 ft. of lumber.

Chuquicamata Leaching Plant.[1]—For an outline of the process see Mineral Industry, **22**, 870 and **23**, 259. The plant has a capacity in the first of the four units of 10,000 tons of ore daily per unit in 18 hr. operation, leaving 6 hr. for inspection and repairs.

The plant is 9500 ft. above sea level and 500 ft. lower than the ore-body nearly 3 miles distant, and is situated on a 6¼ per cent. slope.

There are nine tanks for the acid solution storage varying from 150 by 130 ft. down to 150 by 70 ft., all 12 ft. deep. The six leaching vats are

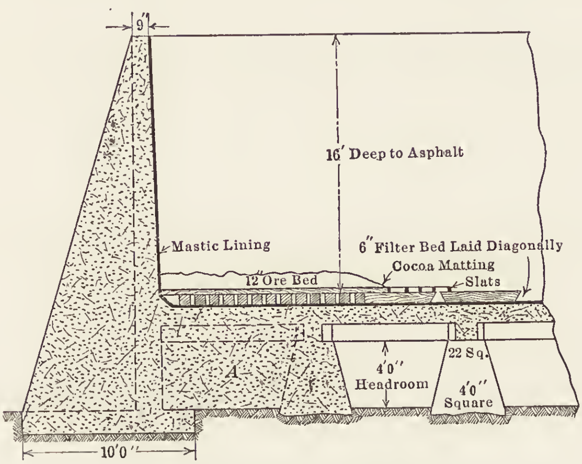


Fig. 3.—Part section of leaching vat.

110 ft. wide, 160 ft. long and all 16 ft. deep, set end to end in line parallel to and 80 ft. from the solution tanks and 20 ft. lower.

Fig. 3 shows a part section of a 10,000-ton leaching vat, and shows the cantilever portion of the counterfort at *A*, carried under the floor-level and keyed to the first pier, all to resist the tendency to overturn the wall. The vat is of concrete, the floor panels reinforced with ⅝-in. and ½-in. steel bars at 4½-in. centers, the beams with 1-in. bars hooked into the buttresses. The buttresses are reinforced with 1½-in. bars on the tension side and with ⅝-in. and ½-in. bars on the compression side, also bars placed horizontally in the wall. The floor is lined with asphalt, the sides with mastic, and the vat is provided with a false bottom as shown in the figure.

[1] *Min. Mag.* **12**, 274; *Bull. Amer. Inst. Min. Eng.*, Apr., 1915, 723; *Min. Sci. Press*, **112**, 124.

The mastic lining, 1½ in. thick, was a mixture of asphalt and natural gravel mixed in mixing machines while in melted condition. This was poured behind special sheet-steel forms, 6 in. wide, the forms being raised after each 6-in. layer was set. To attach the lining, and to prevent creep, wires were embedded in the concrete at 24-in. centers, and to these were secured a light expanded metal reinforcement set in the center of the lining. To allow for expansion of the concrete floor without cracking the bottom lining a deadening felted paper, ¹⁄₁₆ in. thick, was laid, and on this the 2-in. asphalt lining reinforced with expanded metal at its central plane. The filter-bottom is of 6 by 6-in. pieces overlaid with slats and cocoa matting, and 12 in. of ore is always left above the matting for protection against the unloading grab.

To unload these vats, 110 ft. wide, there are provided two structural-steel bridges, one for loading, one for unloading, both spanning and traversing from end to end the line of vats. The smaller or loading bridge

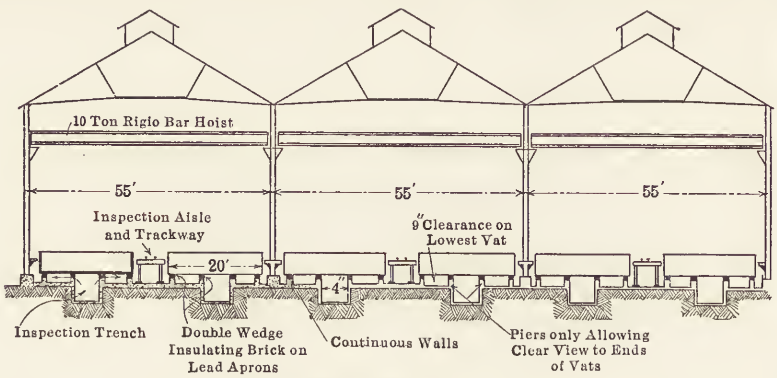


Fig. 4.—Electrolytic tank-house.

has a clear span of 124 ft. and a cantilever of 20 ft. at one end. The bridge is electrically driven along the trackway. The crushed ore, after passing through a sampling tower, is fed on a 36-in. carrying belt, which runs the whole length of the beds, and passes through a tripper placed on the cantilever of the bridge. It is thus delivered to a short 36-in. conveying belt running the length of the filling bridge and across the vats. The unloading bridge has a clear span of 150 ft., and there are works over and outside of the loading bridge. The removal of the exhausted ore is done by means of a 6-ton grab, from which it is discharged into a hopper placed at one end of the bridge, this hopper having a double-way chute leading either to the tailings conveyor system or to railway cars.

The electrolytic plant, Fig. 4, consists of a steel frame building 540 ft. long by 160 ft. wide, containing 540 electrolytic vats, and a cathode-making division. Each tank is 20 ft. long, 5 ft. 3 in. wide and 5 ft. deep, with walls and bottom 5 in. thick of reinforced concrete. Between the tanks run air-locomotives on special tracks, for the removal of the completed cathodes. Sixteen vats form a solution circuit, stepping down 1 in. successively. The flow from each solution circuit flows through cross-building collection launders of concrete lined with mastic, and thence, by a main collecting launder, outside the building to the pump-house head vats to be raised to main solution sumps or storage vats. The building is divided into five electrical circuits, having copper leads 10 by 5/8-in. cross-section, and two bars per circuit. The flow of solution through the electrolytic vats is controlled from a reinforced, concrete head-tank, nearly 95 ft. long, 61 ft. wide and 12 ft. deep. It is in turn regulated by an automatic pumping plant dealing with solutions as they are delivered from the de-chlorinating plant.

The steam power station, to supply current, is situated at Tocopilla on the sea coast, 120 miles distant. It is equipped with four sets of steam turbines and Siemen's generators. Each set will generate 10,000 kw. at 5000 volts, which is stepped up to 110,000 volts for transmission to the plant. Seven motor generators provide direct current for the electrolytic plant.

Leaching at the Nevada-Douglass Mine.[1]—There is a 250-ton plant at this mine, situated in Lyon County, Nev. Both sulphide and oxidized ores are treated.

The sulphide ores are submitted to sulphuric-acid treatment under pressure in a closed receptacle, the iron and copper sulphides being brought into solution as sulphates. The decanted solution is passed through electrolytic cells where the copper is deposited. The remaining iron sulphate solution then goes to an evaporating tower where the liquor is evaporated to the crystallization point and the ferrous and ferric sulphate crystals separate. These crystals are dried at a temperature which will drive off the water of crystallization.

To prepare the sulphuric acid the dried sulphates are roasted in a Wedge furnace at a temperature high enough to decompose the sulphates, throwing off sulphur trioxide. This is collected in absorption towers, where in presence of water vapor, H_2SO_4 is produced for leaching the oxidized ores. The ferric oxide remaining is sold.

Leaching of the oxidized ore is carried on in Pachuca tanks, where the ore in suspension in the acid solution is agitated with air. The copper-bearing decanted solution is passed through electrolytic cells where the copper is taken out, the exhausted solution evaporated to the crystallization point, and the crystals dried and roasted as above described for the

[1] *Min. Sci. Press*, **3**, 485.

production of sulphuric acid. Some sulphur dioxide may be formed and lost, and some acid wasted in presence of lime in the ore.

The cost of mining and treating sulphide ores is $5.18 per ton. An ore a little above 3 per cent. in copper, and allowing for some loss in treatment, should yield $12 per ton, giving a net profit of $6.82 per ton of ore treated.

Leaching at Yerington, Nev.[1]—The Walker River Copper Co. has been incorporated under the auspices of the General Development Co. to work the Copper Flat property, two miles west of Yerington, where is an estimated quantity of 2,000,000 tons of 2.5 per cent. copper ore.

The ore is leached with an acidulated solution containing 3 per cent. ferric chloride and 5 per cent. salt. The copper-bearing solution is then precipitated on granulated iron in tumbling barrels, and a barren solution of ferrous chloride flows away. This is regenerated to the ferric salt by treatment in electrolytic cells at a current density of 4 to 5 amp. per sq. ft. and a voltage of 3 to 4 volts. Metallic iron is deposited and chlorine set free, regenerating ferric chloride.

Treatment of Arizona Porphyry Ores.[2]—R. R. Goodrich gives the steps as oxidizing, roasting, leaching with sulphuric acid, and electrolytic precipitation of the dissolved metal.

The ore, ground to 20 to 80-mesh, is roasted in 1¼ to 2 hr. at between 600° C. and 725° C. to produce the maximum amount of soluble copper.

Leaching is preferably done with a 10 per cent. solution of H_2SO_4 heated to 100°C., and the copper extracted in 3 to 6 hr.

Even when using carbon anodes, sulphur dioxide gas depolarizes only to the extent of 45 to 65 per cent. of the theoretical amount. It varies with the current density, being at a maximum with a low current. However, introduced into the electrolyte, the solution should be fully saturated with the sulphur dioxide. So used, the copper deposit is smoother and deposition of copper can be carried farther, while with no SO_2 present, the deposited surface becomes spongy.

By a step arrangement of process the electrolyte is maintained with the same content in copper in the successive cells. In this way a liquor strong in copper flows to the electrolytic plant constantly, and the outflow is well depleted of copper. Circulation of the electrolyte by this step arrangement increases the current efficiency.

[1] *Min. Sci. Press*, **111**, 94.
Bull. Amer. Inst. Min. Eng. Oct., 1915.

CRYOLITE

The only known commercial deposit of cryolite occurs at Ivigtut in Arauk Fjord, South Greenland. Most mining engineers are familiar with the deposit through specimens of the mineral, but few have visited the locality. Not only is the deposit interesting from the fact that this unusual mineral is found in great quantity, but also because it is one of the finest examples of an ore deposit in a pegmatite.

Cryolite was first made known to Europeans by Greenland Esquimaux 1798. Exploitation began about the year 1852, a Danish chemist having discovered a method of producing soda and aluminium from cryolite. For many years a steady production was maintained, and though the value of the material as a source of soda is now negligible, the enamel industry still makes its production profitable.

Cryolite occurs in a small area of porphyritic granite enclosed in older granitic gneiss, as a large irregular mass. Originally at the surface it formed an elongated outcrop about 150 m. long and 30 m. wide, with a northeast-southwest axis. As the deposit was opened, it was found to be much larger than the outcrop indicated. It broadened and dipped under the country rock to the east. The boundary in this direction is marked by a pegmatite vein in which a number of rare minerals have been found, including ivigtite and columbite, while cassiterite and molybdenite are also present. The cryolite is of pegmatitic origin. In mining, two grades are recognized, the "white" and "black." The "white" contains about 90 per cent. to 95 per cent. cryolite, the remainder being pyrite, galena, and siderite. The mineral of this grade is shipped to Copenhagen. The "black" contains beside the above impurities a large amount of fluorite. This grade is shipped to Philadelphia, and is valued at about $20 per ton.

Mining has been by open cut. Until recently primitive methods were used, but in the last few years dynamite has replaced gun-powder, an air compressor and drills have been installed, and a modern double-drum hoist operates cages in a steel shaftway placed on the side of the open cut. A curiously antiquated method of handling the product is practised. After being shot down, it is shovelled into barrows after hand sorting, dumped on a platform, washed, and shovelled into cars. The cars are hoisted and trammed to a wooden platform. Here the mineral is dumped on a pile, the larger pieces being used to build a wall, and the wall laid to line. The cryolite is worked into the pile to avoid air spaces, and the top carefully levelled. The main reason for making these piles is that the cryolite may be measured by the Government's representative, the concession being granted on a tax based on the number of cubic meters shipped per year. The scale of the taxes at present is given in the table printed on the succeeding column.

Cubic Meters per Annum.	Kroner[1] per Cubic Meter.
White Cryolite:	
Up to 4000	120
4000–7000	90
7000–8000	100
8000–9000	110
Additional output	120
Black cryolite	48

Communication during the spring is hazardous because of the ice. The first ship from Europe usually arrives in April, while the last vessel leaves about the first of November. As a consequence during 4 or 5 months of the year, the mine is completely isolated. Forty to 50 men are employed the year round, but during the summer this number is increased by 50 or 60 brought by the first vessel in the spring. These extra men leave by the last boat in the autumn.[2]

The production at the mine for the calendar year 1913 amounted to 10,415 metric tons of cryolite. Of this 8451 tons was treated at the works in Copenhagen, and the balance, namely, 1964 tons, was shipped directly from Greenland to the United States. The production for 1914 amounted to 11,512 tons, of which 4139 tons was shipped to the United States and 7373 tons to Copenhagen. In 1915, 3753 tons was shipped to the United States and 5809 tons to Copenhagen, a total of 9562 tons.

The preparation for the market and the uses of cryolite are described in MINERAL INDUSTRY, **20**, 263.

Formerly cryolite was used in the soda and alum industry and the manufacture of hydrofluoric acid, but now it is used almost entirely in the metallurgy of aluminium and for white opalescent glasses and enamels. The Pennsylvania Salt Co. is the sole importer in the United States.

The Department of Commerce reports the following imports for the fiscal year ending June 30:

	Long Tons.	Value.	Price per Ton.
1911	2007	$47,093	$23.50
1912	2126	48,293	22.70
1913	2519	52,440	20.80
1914	2157	47,435	21.99
1915	4569	91,417	20.01

Canada is also an important producer of aluminium and the importations of cryolite for the year 1912 were valued at $56,591, for 1913, $50,905, and $44,683 for 1914. The cryolite is imported practically entirely from the United States.

[1] One kroner is about 1s. 1d. or 26 cts.
[2] Abstracted from C. P. Bernard, *Min. Mag.*, Apr., 1916.

FELDSPAR

By Arthur S. Watts

The marketed production of feldspar in 1915 was nearly 16 per cent. less in quantity than in 1914. On the other hand, the decrease in value was very slight because of a small increase in the price per ton of crude spar and a material increase in the price per ton of ground spar; also, because of a larger proportion of spar first marketed in ground form. The quantity and value for 1915 were also less than for 1913 but much greater than for former years.

FELDSPAR PRODUCTION FOR 1914 AND 1915

1914

State.	Crude.		Ground.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California	2,778	$10,715	....	....	2,778	$10,715
Connecticut	11,099	42,965	5,414	$40,326	16,513	83,291
Delaware	(e)	(e)	....	....	(e)	(e)
Maine	12,553	30,925	17,510	163,635	30,063	194,560
Maryland	5,867	19,224	42	210	5,909	19,434
Minnesota	....	....	....	....	....	....
New Hampshire	(e)	(e)	....	....	(e)	(e)
New York	289	1,032	19,290	100,995	19,579	102,027
North Carolina	15,420	43,153	....	....	15,420	43,153
Pennsylvania	2,843	10,162	7,258	61,231	10,101	71,393
Vermont†	....	....	....	....	....	....
Virginia	(f)35,056	(f)105,300	....	....	35,056	105,300
Total	$85,905	263,476	49,514	$366,397	135,419	$629,873

1915

State.	Crude.		Ground.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
California	(a)	(a)	(a)	(a)	2,004	$9,550
Connecticut	(a)	(a)	(a)	(a)	13,510	73,124
Delaware	....	....	....	....	....	....
Maine	(a)	(a)	(a)	(a)	27,878	191,456
Maryland	12,485	$36,861	....	....	12,485	36,861
New Hampshire	(b)	(b)	....	....	(b)	(b)
New York	(a)	(a)	(a)	(a)	17,375	65,988
North Carolina	(a)	(a)	....	....	(c)24,687	(c)131,393
Pennsylvania	(a)	(a)	(a)	(a)	15,830	120,984
Virginia	(b)	(b)	....	....	(b)	(b)
	60,811	$188,443	52,958	$440,913	113,769	$629,365

(a) Figures withheld to avoid disclosing individual production.
(b) New Hampshire and Virginia included in North Carolina.
(c) North Carolina includes Virginia and New Hampshire, and also a quantity of feldspar mined in North Carolina, but before being marketed, ground in Tennessee.
(e) Included in Virginia.
(f) Virginia includes Delaware and New Hampshire.

The average price for spar sold crude in 1915 was $3.46 per long ton as compared with $3.43 in 1914 and $3.41 in 1913 (equivalent values per short ton, $3.12, $3.07, and $3.31). The average price in 1915 of ground spar was $8.33 per short ton as compared with $7.40 in 1914 and $8.31 in 1913. The average price per short ton for the entire production in 1915, that is, combined sales of both crude and ground spar was \$5.54, as compared with \$4.77 in 1914 and with \$6.49 in 1913. Of the total marketed product of 1915 about 53.5 per cent. was sold crude and 46.5 per cent. was sold ground.

PRODUCTION OF FELDSPAR 1911–1915 IN SHORT TONS

Years.	Crude.		Ground.		Total.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
1911	28,131	\$88,394	64,569	\$490,614	92,700	\$579,008
1912	26,462	89,001	60,110	431,561	86,572	520,562
1913	45,391	148,549	75,564	628,002	120,955	776,551
1914	85,905	263,476	49,514	366,397	135,419	629,873
1915	60,811	188,443	52,958	440,913	113,769	629,356

The 1915 production of feldspar in the Dominion of Canada was 15,455 tons, valued at \$59,124 or an average of \$3.18 per ton as compared with a production in 1914 of 18,060 tons valued at \$70,824 or an average of \$3.29 per ton. The year's production is slightly less than the average of the preceding 6 years. As usual by far the greater proportion of the production came from Frontenac County, Ontario. It is of interest to note, however, that there has been a renewal of feldspar mining in Hull Township, Quebec.[1]

An investigation of Georgia feldspars[2] has just been completed and shows a variety of feldspars in that State not previously reported. The most promising are the following:

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
SiO_2	62.74	63.75	64.75	70.70	72.36
Al_2O_3	21.08	20.38	19.86	17.06	16.68
Fe_2O_3	0.40	0.24	0.18	0.48	0.48
CaO	....	0.03	....	0.23	0.56
MgO	0.03	trace	....	0.04	0.08
Na_2O	1.09	3.34	2.56	2.80	7.84
K_2O	14.84	11.48	12.46	8.44	1.44
Ign. loss	0.18	0.62	....	0.36	0.50

No. 1. From near Lynchburg, Putnam County, Ga.; No. 2. From near Elberton, Elberton County, Ga.; No. 3. From Kell mica mine, Raburn County, Ga.; No. 4. From near Hiram, Paulding County, Ga.; No. 5. From Robertstown, White County, Ga.

The other analyses reported showed 0.80 per cent. or more Fe_2O_3 and would not be acceptable for ceramic uses although they would be satisfactory for use in scouring soaps, poultry grit, and the various other products for which feldspar is now employed.

The largest deposit reported is a dike of 70 ft. maximum width located ⅛ mile above Thompson's Bridge over Hodge Creek, 4 miles northwest of Comer, Madison County. This deposit appears to be a mixture of approximately equal parts potash and soda feldspar mixed with an equal amount of quartz.

The consumers of ground feldspar have during the past year been giving increased attention to the degree of pulverization attained in com-

[1] Preliminary Report, Mineral Production of Canada, 1915. [2] Ga. Geol. Surv., *Bull.* 30, 1915.

mercial feldspars and a marked improvement in uniformity of products has been reported wherever uniformity of pulverization was maintained. The following table shows the difference to be expected from different grinding periods, all other factors being constant.

CLASSIFICATION OF FELDSPAR, GROUND FOR DEFINITE LENGTHS OF TIME UNDER UNIFORM CONDITIONS[1]

Length of Grinding Period.	Crushed Only, Per Cent.	6 Hr.	8 Hr.	10 Hr.	12 Hr.
Residue on 80-mesh sieve	48.740	......	......	......	......
Residue on 100-mesh sieve. Average diameter of grain 0.205 mm	3.000	0.225	0.190	0.170	0.0625
Residue on 150-mesh sieve. Average diameter of grain 0.157 mm	6.664	1.392	0.470	0.268	0.1775
Residue on 200-mesh sieve. Average diameter of grain 0.110 mm	5.810	3.018	2.078	1.705	0.455
Residue on 260-mesh sieve. Average diameter of grain 0.0765 mm	4.020	7.380	5.520	4.215	3.372
Residue on 330-mesh sieve. Average diameter of grain 0.0578 mm	4.680	6.758	5.650	4.590	4.565
Residue in Elutriator Jars 80 c.c. per Min. Flow					
No. 1 elutriator. Average diameter of grain 0.0314 mm	7.780	17.180	14.840	12.835	11.50
No. 2 elutriator. Average diameter of grain 0.0187 mm	2.536	11.030	11.660	11.800	12.325
No. 3 elutriator. Average diameter of grain 0.010 mm	6.540	14.765	17.855	17.385	19.375
Overflow from No. 3 elutriator	8.540	36.913	40.850	45.643	47.425

The data presented indicates that pulverization can not be economically carried beyond that degree accomplished by 10 hr. grinding under the conditions of this test.

Investigations concerning the behavior of mixed potash and soda feldspars in porcelains[2] indicate that equal proportions of potash and soda feldspar produce the most warping at temperatures of cone 8 and below and that above this temperature increase in warping is noted with increase of soda feldspar content until a feldspar-content containing 83 per cent. soda feldspar is reached. The greatest shrinkage was found in porcelains containing equal amounts of potash and soda feldspar. The translucency of the porcelains increased with substitution of soda feldspar for potash feldspar provided the temperature did not exceed cone 8. Above this temperature, translucency decreased with replacement of potash feldspar by soda feldspar. An investigation of dental porcelains[3] indicates that artificial teeth contain about 61 per cent. potash feldspar, 20 per cent. soda feldspar, 4 per cent. kaolin and 15 per cent. flint.

[1] *Trans. Amer. Cer. Soc.*, **16**, 133.
[2] *Trans. Amer. Cer. Soc.*, **16**, 212.
[3] *Trans. Amer. Cer. Soc.*, **17**, 190.

FLUORSPAR

All records for the amount of domestic fluorspar mined and marketed in the United States were broken in 1915, when 136,941 short tons, valued at $764,475, was sold, compared with 95,116 short tons, valued at $570,041 in 1914. Compared with the next highest year, 1912, the output in 1915 represents an increase, according to the U. S. Geological Survey, of more than 20,000 tons, or nearly 18 per cent. As usual the bulk of the fluorspar produced was sold as gravel spar, the quantity in 1915 amounting to 114,151 short tons, or 83 per cent. of the total.

DOMESTIC FLUORSPAR SOLD, 1913–1915

State.	Gravel.			Lump.			Ground.			Total.		
	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per Ton.	Quantity (Short Tons).	Value.	Average Price per. Ton	Quantity (Short Tons).	Value.	Average Price per Ton.
1913. Illinois.... Kentucky.	91,663	$525,456	$5.73	5,676	$39,059	$6.88	8,137	$100,203	$12.31	85,854 19,662	$550,815 113,908	$6.42 5.80
Other States (a).	b 10,104	71,568	7.08	(b)	(b)	......	....	....	......	10,104	71,568	7.08
	b101,767	597,024	5.87	5,676	39,059	6.88	8,137	100,203	12.31	115,580	736,286	6.37
1914. Illinois.... Kentucky.	77,048	397,913	5.16	8,842	74,708	8.45	6,998	82,428	11.78	73,811 19,077	426,063 128,986	5.77 6.76
Other States (a).	b 2,228	14,992	6.73	(b)	(b)	......	....	....	......	2,228	14,992	6.73
	b 79,276	412,905	5.21	8,842	74,708	8.45	6,998	82,428	11.78	95,116	570,041	5.99
1915. Illinois.... Kentucky.	112,769	547,415	4.85	12,033	90,337	7.51	10,757	116,161	10.80	135.559	753,913	5.56
Other States (a).	b 1,382	10,562	7.64	(b)	(b)	......	....	....	......	1,382	10,562	7.64
	b114,151	557,977	4.89	b12,033	90,337	7.51	10,757	116,161	10.80	136,941	764,475	5.58

(a) Includes, 1913: Arizona, Colorado, New Hampshire, and New Mexico; 1914: Colorado and New Hampshire; 1915: Colorado, New Hampshire, and New Mexico.
(b) Some lump spar is included with gravel.

Sales of fluorspar in 1915 were reported from five States—Illinois, Kentucky, New Hampshire, New Mexico, and Colorado. All showed increases over 1914 except Colorado, where there was a large proportional decrease.

Notwithstanding that the prices of many mineral products, including steel (the production of which practically controls the fluorspar output), increased during 1915, the value of fluorspar declined. The average price per ton for the whole country, considering all grades of fluorspar, was approximately $5.58 in 1915, as compared with $5.99 in 1914, a decrease of 41 cts. a ton. It is interesting to note that in 1912, although the output was about 20,000 tons less than in 1915, the value of the product was $4688 more than in 1915. This decline in value has

PRODUCTION OF FLUORSPAR IN THE UNITED STATES, 1883–1915, IN SHORT TONS

Year.	Quantity.	Valuc.	Year.	Quantity.	Value.
1900	18,450	$94,500	1908	38,785	$225,998
1901	19,586	113,803	1909	50,742	291,747
1902	48,018	271,832	1910	69,427	430,196
1903	42,523	213,617	1911	87,048	611,447
1904	36,452	234,755	1912	116,545	769,163
1905	57,385	362,488	1913	115,580	736,286
1906	40,796	244,025	1914	95,116	570,041
1907	49,496	287,342	1915	136,941	764,475

been caused largely as a result of improvements in methods of milling, and in handling larger quantities of spar in the Illinois-Kentucky district. The decline in price from 1914 to 1915, however, has more significance. The demand for spar was unusually good and the competition from foreign spar very light, so that conditions were favorable for high prices. Some fluorspar may have been sold on contracts at low prices a long time in advance, but it is also believed that the large producers voluntarily kept the price down to a small margin of profit in order to procure and hold for domestic spar eastern markets which have formerly been supplied largely by imported spar.

The imports of fluorspar have been steadily declining for a number of years. In 1915 there were imported into the United States for consumption 7167 short tons, valued at $22,878, compared with 10,205 short tons, valued at $38,943 in 1914. The large falling off in imports in 1915 may, of course, be attributed in part to the interruptions to commerce caused by the war, as well as to depression in the mining industry in Great Britain, from which country most of our imports come. According to the prices reported, including the duty of $1.50 a ton but excluding freight charges, the average cost of imported spar to the

FLUORSPAR IMPORTED, 1909–1914, IN SHORT TONS. (*a*)

	Quantity.	Value.	Average price per Ton.
1909	6,971	$26,377	$3.78
1910	42,488	135,152	3.18
1911	32,764	80,592	2.46
1912	26,176	71,616	2.74
1913	22,682	71,463	3.15
1914	10,205	38,943	3.82
1915	7,167	22,878	3.19

(*a*) Statistics according to Bureau of Foreign and Domestic Commerce, Department of Commerce

consumer was $4.69 a ton compared with $4.89 for domestic gravel spar at the mines or mills. Even though domestic spar should be sold at the mines or mills at a price slightly lower than that of imported spar at the dock, an advantage in price would still be enjoyed by the imported spar at eastern steel plants, owing to less freight charges on account of a shorter haul. However, the mechanically treated spar from Illinois and Kentucky is of a higher grade than foreign spar, and since fluorspar is of value chiefly according to its purity, purchasers find that the purer American spar is more efficient and consequently cheaper in the end.

The large amount of fluorspar sold in 1915 may be accounted for principally because of the great demand for steel. It is estimated that about 80 per cent. of the American fluorspar output, mainly in the form of gravel spar, is consumed in the manufacture of basic open-hearth steel.

FLUORSPAR OUTPUT OF THE PRINCIPAL PRODUCING COUNTRIES
(In metric tons)

Year.	Austria-Hungary.	France.	Germany: (a)	Spain.	United Kingdom.	United States.
1904	7,061	2,047	13,540	(b)	18,451	33,062
1905	7,601	2,434	13,019	(b)	40,079	52,048
1906	7,795	4,218	15,493	70	42,512	37,002
1907	8,779	4,795	16,624	270	50,257	44,884
1908	7,359	5,456	14,925	253	35,257	46,023
1909	8,106	5,725	14,545	246	43,165	62,970
1910	(e)8,000	8,264	17,988	180	62,607	62,970
1911	*Nil.*	9,502	23,073	490	32,100	78,953
1912	....	....	21,023	265	29,152	105,712
1913	....	....	....	351	54,557	104,882

(a) Exports. German statistics no longer report production. (b) Not reported. (e) Estimate.

Great Britain.[1]—The production 20 years ago was less than 5000 tons, but the figures have gradually risen until the 1913 production amounted to 54,557 metric tons. The relative rate of increase was governed to some extent by alterations in the American import duty. Until 1909 English fluorspar was imported duty free, and in this year a tax of $3 per ton was imposed, practically doubling the price. The result was a fall in the English output. In 1913 the tax was reduced to $1.50 and the English production then slightly revived. The imposition of the tax in 1909 so greatly increased the price that means had to be sought here to obtain a cheaper product, so the old waste dumps were picked over and washed. During the year 1911 nearly 90 per cent. of the Derbyshire supplies came from this source, but these resources are now dwindling. The chief producing districts in the United States are in Illinois and Kentucky, and the incidence of railway charges is such that English fluorspar can compete with the American article as far west as Pittsburgh.

[1] *Min. Mag.*, May, 1916.

In Great Britain the producing centers are in Derbyshire, Durham, Cornwall, and Flint, but only the first two are of commercial importance. In Cornwall the fluorspar is found in metalliferous veins traversing Devonian rocks. In Derbyshire, Flint, and Durham it is found in galena and galena-blende lodes traversing rocks of Carboniferous age, in the first two Carboniferous limestone and in the last named chiefly the Yoredale grits and shales. In Derbyshire the fluorspar is associated with barite and in Durham with silica. The presence of silica is not disadvantageous in the American trade. In Flint the fluorspar is so finely distributed and associated with so many other gangue minerals that it can not be collected commercially. The mining of fluorspar in Derbyshire and Durham is an adjunct to lead mining. In Durham the chief producing center is near the head of Weardale, and the yield comes mostly from the mines of the Weardale Lead Co., other owners of properties being George G. Blackwell, Sons & Co., Hird, Waistell & Co., and the Weardale Steel, Coal & Coke Co. The chief mines are the Sedling, Boltsburn, Stotfield Burn, Stanhope Burn, and Crawley, belonging to the Weardale Lead Co., the Barbary belonging to Blackwells, Park Burn Heights belonging to Hird, Waistell & Co., and the Hope Level and Crawley belonging to the Weardale Steel Co. There are mines also, over the borders of Northumberland and Cumberland, of which the Rotherhope at Alston belonging to the Vieille Montagne Zinc Co. is a small producer. At all these mines three grades of commercial products are obtained, the handpicked "lump," and "gravel" and "sand" from the jigs. The lump, of course, is the cleanest and best quality on the market.

Derbyshire is the oldest and best-known center in England for the production of fluorspar, where the mineral is found filling veins and other cavities in the Carboniferous limestone. Usually it is confined to the uppermost 300 or 400 ft. of the formation, so that the producing mines are along the margin of the limestone massif, especially the eastern margin. Below this depth the mineral is replaced by barite and calcite. Quartz is very rarely found in the veins. All the mines were originally worked for lead. They can be grouped into seven districts: Castleton, Bradwell, Eyam, Calver, Matlock, Ashover, and Crich. Castleton is renowned for the ancient Odin and "Blue John" mines, producing the variety of fluorspar prized by makers of ornaments. Eight other mines are also producing, and many others besides are known to contain fluorspar veins. It is believed that very extensive amounts of the mineral are accessible. As an example of the method of working, we may quote the Grove Syndicate's mine at Calver, 4 miles north of Bakewell. Here the lode varies in width from 2 to 30 ft., with an average of about 8 ft., and it is filled with galena and fluorspar, which are mined together. After hand-picking, the ore is broken and then passed through Krom rolls. By means of screens and hydraulic classifiers the crushed ore is separated into four products, the three coarse being treated in jigs and the fine on vanners. The spar from the jigs is classed as gravel, and that from the vanners as sand. The output of ore, galena. and fluorspar is about 100 tons per week.

In Cornwall fluorspar is found in the killas or Devonian shales and is usually associated with copper minerals. Where the veins are in granite, fluorspar disappears with the copper minerals, and cassiterite and wolfram are found instead. The largest deposit worked recently was found in the Hingston Downs mine near Callington, belonging to the Clitters United Mines, Ltd., where in 1906 a vein of spar 20 ft. wide was struck. Fluorspar has also been found in the districts of St. Agnes, Lostwithiel, Redruth, and Camborne, not at any mine at present working, but on the dumps.

FULLER'S EARTH

By E. H. Sellards

The total production of fuller's earth in the United States during 1915 was 47,901 short tons, an increase over the preceding year of 6920 tons. In addition to that produced there was imported into the United States during 1915, 19,441 short tons. Some fuller's earth is exported from the United States, although the amount can not be determined owing to the fact that this product is not listed separately from other clays.

The States producing fuller's earth at present are Arkansas, California, Florida, Georgia, Massachusetts, and Texas. Of these Florida is the chief producer, the output from this State amounting to approximately three-fourths of the whole output for the United States. The value of the fuller's earth produced in the United States during 1915 was $489,219.

Clays having the properties of fuller's earth more or less well developed are widely distributed in the United States and are confined to no particular geological horizon, although the largest known deposits are of Cenozoic age. By far the greater part of fuller's earth is in the form of a sedimentary deposit which is distinctly stratified, and from which an overburden must be removed in mining. In Arkansas, however, fuller's earth is known that is exceptional in that it is residual, having been formed *in situ* from the disintegration of basaltic dykes. In the United States fuller's earth is known from the following States: Alabama, Arizona, California, Colorado, Florida, Georgia, Massachusetts, Minnesota, Mississippi, New York, South Carolina, South Dakota, Texas and Utah. Of these States, however, only six as noted in the paragraph above are actually producing fuller's earth at present.

STATISTICS OF FULLER'S EARTH IN THE UNITED STATES
(In tons of 2000 lb.)

Year.	Production.		Imports.		Years.	Production.		Imports.	
	Sh. Tons.	Value.	Sh. Tons.	Value.		Sh. Tons.	Value.	Sh. Tons.	Value.
1904......	29,480	$168,500	10,221	$74,000	1910......	30,857	$277,293	16,857	$132,545
1905......	25,745	157,776	15,181	105,997	1911......	34,668	335,350	18,224	143,594
1906......	28,000	237,950	14,827	108,696	1912......	32,715	305,522	19,109	145,337
1907......	34,039	323,275	14,648	122,221	1913......	38,594	369,750	18,628	145,588
1908......	30,517	270,685	12,279	93,413	1914......	40,981	403,646	24,974	195,083
1909......	29,561	289,000	12,752	101,151	1915......	47,901	489,219	19,441	152,493

GOLD AND SILVER

The gold production of the world during 1915, according to such figures as are at present available, supplemented by preliminary estimates, showed a rise in production amounting to about 4 or 5 per cent., as compared with a previous drop of 1 per cent. In fact the production is turning out to be even more than was anticipated in some cases, since the later estimates run higher than the earlier ones. That this is not an abnormal result in the face of existing conditions, can be seen when one realizes that none of the great gold-producing areas of the world have been directly affected by the war. On the other hand, in many cases the production has probably been stimulated somewhat by the demand for gold by the belligerent nations, particularly in the case of the British Colonies, these being responsible for a large proportion of the increase. This, however, has not amounted to a great deal, as is evidenced by the fact that the increase in production is small as compared with the total British production, which amounts to over 60 per cent. of the total world's production, and also by the fact that the only large decrease in production was in Australia. In fact the war has interfered less with the production of gold than with any other metal, and it is possible to discuss the output from the standpoint of mining conditions, without taking particular consideration of the war conditions that are so markedly affecting almost all of the other metals.

GOLD AND SILVER PRODUCTION OF THE WORLD, 1493–1850
According to Dr. Adolph Soetbeer

Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.	Period.	Estimated Production in Kilograms.		Ratio of Silver to Gold. Weight.	Ratio of Gold to Silver. Value.
	Gold.	Silver.				Gold.	Silver.		
1493–1520	162,400	1,316,000	8.1	10.75	1701–1720	256,400	7,112,000	27.7	15.21
1521–1544	171,840	2,164,800	12.6	11.25	1721–1740	381,600	8,624,000	22.6	15.08
1545–1560	136,160	4,985,600	36.6	11.30	1740–1760	492,200	10,662,900	21.7	14.75
1561–1580	136,800	5,990,000	43.8	11.50	1761–1780	414,100	13,054,800	31.5	14.73
1581–1600	147,600	8,378,000	56.8	11.80	1781–1800	355,800	17,581,200	49.4	15.09
1601–1620	170,400	8,458,000	49.6	12.25	1801–1810	177,780	8,941,500	50.3	15.61
1621–1640	166,000	7,872,000	47.4	14.00	1811–1820	114,450	5,407,700	47.2	15.51
1641–1660	175,400	7,326,000	41.8	14.50	1821–1830	142,160	4,605,600	32.4	15.80
1661–1680	185,200	6,740,000	36.4	15.00	1831–1840	202,890	5,964,500	29.4	15.75
1681–1700	215,300	6,838,000	31.8	14.97	1841–1850	547,590	7,804,150	14.3	15.83

GOLD PRODUCTION OF THE WORLD, 1851–1915

Year.	Value.	Year.	Value.	Year.	Value.	Year.	Value.
1851....	$67,600,000	1871...	$107,000,000	1891 ..	$130,650,000	1911...	$464,346,495
1852....	132,800,000	1872...	99,600,000	1892...	146,292,600	1912...	474,322,664
1853....	155,500,000	1873...	96,200,000	1893...	158,437,551	1913...	462,669,558
1854....	127,500,000	1874...	90,800,000	1894...	182,509,283	1914...	455,676,600
1855....	135,100,000	1875...	97,500,000	1895...	198,995,741	1915...	476,208,000
1856....	147,600,000	1876 ..	103,700,000	1896...	211,242,081	....	....
1857....	133,300,000	1877...	114,000,000	1897...	237,833,984	....	....
1858....	124,700,000	1878...	119,000,000	1898...	287,327,833	....	....
1859....	124,900,000	1879...	109,000,000	1899...	311,505,947	....	....
1860....	119,300,000	1880...	106,600,000	1900...	258,829,703	....	....
1861....	113,800,000	1881...	103,102,000	1901...	260,877,429	....	....
1862....	107,800,000	1882...	102,000,000	1902...	298,812,493	....	....
1863....	107,000,000	1883...	95,400,000	1903...	329,475,401	....	....
1864....	113,000,000	1884...	101,700,000	1904...	349,088,293	....	....
1865....	120,200,000	1885...	108,400,000	1905...	378,411,754	....	....
1866....	121,000,000	1886...	106,000,000	1906...	405,551,022	....	....
1867....	104,000,000	1887...	105,775,000	1907...	416,101,396	....	....
1868....	109,700,000	1888...	110,197,000	1908...	443,355,856	....	....
1869....	106,200,000	1889 ..	123,489,000	1909...	458,424,058	....	....
1870....	106,900,000	1890...	118,848,700	1910...	453,766,523	....	....

SILVER PRODUCTION OF THE WORLD, 1856–1914

Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.	Year.	Kilograms.
1856–1860 .	4,534,950	1883....	2,746,123	1894.....	5,205,065	1905.....	5,638,183
1861–1865 .	5,505,575	1884....	2,788,727	1895.....	5,667,691	1906.....	5,683,947
1866–1870..	6,695,425	1885....	2,993,805	1896.....	5,496,178	1907.....	5,704,083
1871–1875 .	9,847,125	1886....	2,902,471	1897.....	5,663,304	1908.....	6,612,304
1876.......	2,323,729	1887....	2,990,398	1898.....	5,575,336	1909.....	7,069,656
1877.......	2,388,612	1888....	3,385,606	1899.....	5,529,024	1910.....	7,471,663
1878.......	2,551,364	1889....	3,901,809	1900.....	5,599,216	1911.....	7,906,446
1879.......	2,507,507	1890....	4,180,532	1901.....	5,438,443	1912.....	7,804,516
1880.......	2,499,998	1891....	4,479,649	1902.....	5,121,469	1913.....	6,964,361
1881.......	2,592,639	1892....	4,985,855	1903.....	5,386,044	1914.....	6,566,615
1882.......	2,769,065	1893....	5,339,746	1904.....	5,669,124	....	....

(*e*) Estimated. 1 kilogram = 32.15 Troy ounces.

The future of gold mining is good. The commercial upheaval caused by the war has served to emphasize the fact that the man who has got gold to sell is sure of his market. Though the gold mines suffer with others from the increased cost of supplies, labor, and transportation, and there is shortage at the mines as elsewhere of both men and equipment, the war conditions raise the value of the output. Where a choice is offered investors are the more ready, because of the war, to put money into gold mines. The fact that heavy taxes must be met in the future merely reinforces the necessity for security and large yield in making investments. The growing interest in the Far Eastern Rand, makes it possible that new mines will be brought into production there at a rate compensatory to the decrease on the Central Rand. That the gold ultimately to be mined from the East Rand is sufficient to keep up the output for many years is becoming more and more certain. No new fields of great promise are in sight at the moment, though expansion in Canada, Siberia, and the Philippines may be anticipated. Elsewhere increased yield must come mainly from more extensive working

GOLD PRODUCTION OF THE WORLD

Countries.	1913.			1914.			1915.		
	Oz. Fine.	Kilograms.	Value.	Oz. Fine.	Kilograms.	Value.	Oz. Fine.	Kilograms.	Value.
America, North:									
United States....	(d)4,299,784	133,741	$88,844,400	(d)4572,976	139,731	$94,531,800	(a)4887,604	157,158	$101,035,700
Canada....	(a)802,973	24,976	16,598,923	(a)773,178	23,962	15,983,007	916,076	28,494	18,936,971
Mexico....	813,083	25,290	16,807,768	(e)879,707	27,363	18,185,000	772,184	24,018	15,962,450
Central America...	(e)146,608	4,560	3,030,400	(e)120,938	3,761	2,500,000	181,275	5,638	3,747,300
America, South:									
Argentina.	(e)5,144	160	107,300	......	......	......	......	......	......
Bolivia....	(e)84,690	263	175,000	......	......	......	......	......	......
Brazil.....	(e)172,700	5,372	3,570,000	(d)130,525	4,060	2,698,192	......	......	......
Chile......	(e)35,365	1,100	731,053	......	......	......	......	......	......
Colombia..	(e)143,768	4,475	2,971,700	(d)226,326	7,040	4,678,000	......	......	......
Ecuador...	(e)19,666	610	406,500	(e)14,512	451	300,000	......	......	......
Guiana, British...	(e)42,564	1,324	879,000	(d)54,495	1,695	1,126,515	50,615	1,574	1,046,300
Guiana, Dutch....	(a)27,640	860	571,100	(d)29,533	919	503,390	......	......	......
Guiana.... French...	(e)147,585	4,594	3,050,600	......	......	......	......	......	......
Peru......	(e)23,328	740	492,200	......	......	......	......	......	......
Uruguay....	(e)5,370	165	111,000	......	......	......	......	......	......
Venezuela..	(e)30,164	939	623,500	......	......	......	......	......	......
Europe:									
Austria....	(a)9,032	281	186,714	(e)7,256	226	150,000	......	......	......
France....	(e)87,668	2,728	1,812,100	(e)70,144	2,182	1,450,000	......	......	......
Hungary...	(a)94,137	2,928	1,945,972	(e)84,656	2,633	1,750,000	......	......	......
Germany..	(d)6,558	204	135,600	......	......	......	......	......	......
Italy......	(a)430	13	8,886	(a)1,191	38	21,589	......	......	......
Russia.....	(d)1,282,304	39,885	26,507,770	1,382,900	43,014	28,587,025	1.412,533	43,936	29,199,600
Portugal..	(e)111	4	2,300						
Sweden....	(a)804	25	16,620	......	......	......	......	......	......
Turkey....	......	......	......	......	......	......	......	......	......
Servia.....	(e)12,148	378	251,100	(d)4,533	141	115,991	......	......	......
United Kingdom.	(a)1,340	40	27,800	(d)864	27	17,860	......	......	......
Africa:									
Congo..... } Madagascar....	(e)98,916	3,064	2,044,600	(e)43,537	1,354	900,000	87,224	2,713	1,804,000
				53,213	1,655	1,100,000	42,242	1,314	973,300
Rhodesia..	(a)689,954	21,460	14,261,343	(a)854,480	26,578	17,423,087	915,029	29,422	18,593,973
Transvaal..	(a)8,794,824	273,930	181,784,223	(a)8,378,139	260,595	173,189,367	9,093,769	282,854	187,984,400
West Coast	(a)379,679	11,810	7,954,450	(e)419,510	13,049	8,404,660	412,273	13,256	8,303,698
Asia:									
Borneo, British...	......	......	......	(e)62,387	1,940	1,289,650	63,564	1,977	1,319,000
British India.....	(a)539,502	16,781	11,152,463	(d)550,432	17,120	11,378,437	557,111	17,328	11,516,600
China.....	(e)176,526	5,510	3,658,900	(e)175,360	5,454	3,625,000	177,744	5,529	3,674,300
E. Indies, British...	(e)65,360	2,036	1,352,000	} (e)226,879	70,57	4,690,000	157,733	4,906	3,260,600
Dutch....	(e)163,860	5,100	3,387,100						
Indo-China	(e)3,614	110	74,700	......	......	......	......	......	......
Formosa...	(d)39,400	1,226	813,944	......	......	......	......	......	......
Japan.....	(a)216,273	6,727	4,470,723	(e)216,551	6,736	4,476,500	......	......	......
Korea.....	(d)173,300	5,390	3,579,673	(e)145,125	4,514	3,000,000	......	......	......
Malay States....	(d)13,661	419	282,400	(d)13,020	405	269,100	11,287	351	243,300
Siam......	(e)2,733	85	56,500	......	......	......	......	......	......
Australasia	(a)2,553,327	79,419	52,781,525	(e)2,414,674	75,106	49,915,336	2,298,372	73,903	48,067,570
Total....	(d)22,249,596	692,055	$459,941,100	(d)22,039,598	685,524	$455,676,600	23,036,600	716,535	$476,208,000

(a) Official statistics of the country. (c) Six states and New Zealand. (d) Report of the Director of the U. S. Mint, 1915. (e) Estimated. (g) Exports.

of low-grade ore, as at Juneau in Alaska, along the Mother Lode in California, and at Cripple Creek in Colorado, and the more extensive working of base metal mines from which gold and silver come as by-products.[1]

Commercial Movement of the Precious Metals[2]

While the European war had little effect on the mining of gold, it had an important influence on the commercial movement of the metal. This was entirely different from what we are accustomed to seeing in normal times. The demand for gold everywhere has been great, and it is probable that an unusually large portion of the gold mined passed into currency either as coin or in bullion used in bank reserves and in the making of exchanges. Certainly a comparatively small amount was employed in the arts, the efforts of European countries being to retain as much as possible in their own hands.

The United States has been the chief beneficiary of the gold production of the year. The extent of our exports to Europe, very far in excess of those of any previous year, was strikingly illustrated, especially in the latter half of the year, by the depression in exchange and by the very large amount of loans made to foreign countries. Of these, the most important was the advance of $500,000,000 to the Allied nations, but there were a number of individual loans made to various countries which we have not room to specify in detail, but which brought the total amount up to more than $900,000,000. These advances were supplemented by the return or re-sale to us of American securities held abroad, the total of which it is impossible to estimate. Besides all this the imports of gold into this country exceeded the exports for the year by about $414,550,000. Adding to this our own gold production of $101,000,000, it will be seen that practically the United States absorbed in 1915 not only the entire gold production of the year, but over $40,000,000 additional and is therefore at present the chief gold-holding nation of the world.

A peculiar situation with regard to the English reserve has developed from the war. The gold from South Africa and Australia, which normally goes direct to London, was largely held in those countries as a reserve which could be drawn upon by the Bank of England in case of necessity, or which could be shipped, if required, to other countries direct. This was done to avoid as far as possible the risks of transit during war times. The returns of the great European banks can not be accepted in the usual sense as commercial balances, except in the case of the Bank of England, and even there the colonial reserves referred to must be taken into account. The Bank of England, at the close of December, 1915,

[1] *Min. Mag.*, Feb., 1916.
[2] *Eng. Min. Jour.*, Jan. 8, 1916.

reported a decrease of $90,085,000 as compared with the close of 1914. On the other hand, the Bank of France showed a gain of $150,000,000 in its gold reserve, that of Germany about $90,000,000 and that of Russia about $30,000,000. These figures are to be accepted with reserve, since the aim of these institutions has been to accumulate as great an amount of gold as possible, while the currency of most of the European nations has been going to a large extent upon a paper basis. What the future result of this movement will be is an interesting problem.

Silver.[1]—The silver market during 1915 was affected by the exceptional conditions which attach to a state of war. It is therefore remarkable that for the first 10 months, the tenor of prices should have been so even in spite of events, which, in normal circumstances, would have left considerable impression. Throughout that period, the price showed great steadiness, and violent fluctuations were practically absent. This is the more worthy of comment when it is remembered that a quotation for forward delivery has not been made since the outbreak of war, because such a quotation forms a steadying factor by affording operators an alternative method of dealing. The demand was by no means the same as in pre-war times. Trade enquiry languished, and the Indian Bazaars for a long period abstained from purchases in London owing to the high rates of insurance and other causes.

An unusual portion of the buying derived from coinage orders on account of the British and foreign mints. As these orders were launched in order to meet urgent requirements for currency, the question of price had little weight, for the profit was ample. On the other hand, sales were almost confined to the United States, Canada, and Mexico, Europe being more a buyer than a seller. The uncertainty as to things financial practically eliminated the speculative element during the period mentioned, as purchases had to be made on a cash basis in the absence of a forward quotation. Bear sales presented difficulty for the same reason. At the beginning of the year, Eastern business, both for the Indian Bazaars and China, figured fairly largely, but the buying on the part of the former was not robust, and fell off as the year advanced.

The scantiness of supplies from Mexico, owing to internal difficulties, prevented the price from easing to any great extent. Threats of submarine interference with merchant shipping, and a falling off in sales from the United States, owing to rising insurance rates, had the effect of lifting the price to a somewhat higher level in March. Under the stress of competing coinage orders, there was a rise, but the upward movement proved too tempting to China, and selling set in from that quarter. Throughout April the market was healthy, being supported by the Indian

[1] Abstract from the "Annual Bullion Letter" of Samuel Montagu & Co., London.

Bazaars and a fair amount of coinage demand. In May shipments from the United States moderated and some Indian speculators bought for a rise. This movement, however, proved short-lived and unprofitable, and prices acquired a sagging tendency; the limited extent of Continental and other demand did not provide the stimulus of competition, while China was a frequent seller. A downward course was pursued until the lowest price of the year, was reached on July 29, 46.87 cts.

A contributory cause to the weakness about this period was anxiety felt as to the course of the monsoon in India, while Mexico was able occasionally to export silver which had to be disposed of on a somewhat unwilling market. On Aug. 9 the United States Treasury commenced to make purchases and continued to buy with some freedom, until the price rose to a higher level. The rise was assisted by the exchange with America moving unfavorably for sellers of silver from that country.

As autumn set in the French coinage demand became insistent, and an important factor in the price. Almost from the beginning of the war complaints were made from all parts of France, including the capital itself, that the amount of 2-franc, 1-franc, and 5-centime coins in circulation was insufficient for commercial transactions. Toward the end of August a mint was established at Castel-Sarrasin.

AVERAGE PRICE OF BAR SILVER IN LONDON, 1840–1905
(In pence per standard ounce, 0.925 fine)

Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.	Year.	Pence.
1840.	60.3750	1850	60.0625	1860	61.6875	1870	60.5625	1880	52.2500	1890	47.6875	1900	28.2500
1841.	60.0625	1851	61.0000	1861	60.8125	1871	60.5000	1881	51.6875	1891	45.0625	1901	27.1875
1842.	59.4375	1852	60.5000	1862	61.4375	1872	60.3125	1882	51.6250	1892	39.8125	1902	24.0900
1843.	59.1875	1853	61.5000	1863	61.3750	1873	59.2500	1883	50.5625	1893	35.6250	1903	24.7500
1844.	59.5000	1854	61.5000	1864	61.3750	1874	58.3125	1884	50.6250	1894	28.9375	1904	26.3990
1845.	59.2500	1855	61.3125	1865	61.0625	1875	56.8750	1885	48.6250	1895	29.8750	......	....
1846.	59.3125	1856	61.3125	1866	61.1250	1876	52.7500	1886	45.3750	1896	30.7500	......	....
1847.	59.6875	1857	61.7500	1867	60.5625	1877	54.8125	1887	44.6250	1897	27.5625	......	....
1848.	59.5000	1858	61.3125	1868	60.5000	1878	52.5625	1888	42.8750	1898	26.4375	......	....
1849.	59.7500	1859	62.0625	1869	60.4375	1879	51.2500	1889	42.6875	1899	27.4375	......	....

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1905....	27.930	28.047	26.794	26.108	26.664	26.910	27.160	27.822	28.528	28.637	29.493	29.977	27.839
1906....	30.113	30.464	29.854	29.984	30.968	30.185	30.113	30.529	31.483	32.148	32.671	32.003	30.868
1907....	31.769	31.852	31.325	30.253	30.471	30.893	31.366	31.637	31.313	28.863	27.154	25.362	30.188
1908....	25.738	25.855	25.570	25.133	24.377	24.760	24.514	23.858	23.877	23.725	22.933	22.493	24.402
1909....	23.843	23.706	23.227	23.708	24.343	24.166	23.519	23.588	23.743	23.502	23.351	24.030	23.706
1910....	24.154	23.794	23.690	24.483	24.797	24.651	25.034	24.428	24.567	25.596	25.680	25.160	24.670
1911 ...	24.865	24.081	24.324	24.595	24.583	24.486	24.286	24.082	24.209	25.594	25.649	25.349	24.592
1912....	25.887	27.190	26.875	27.284	28.038	28.215	27.919	28.375	29.088	29.299	29.012	29.320	28.842
1913....	28.993	28.356	26.669	27.415	27.794	27.195	27.074	27.335	27.985	28.083	27.262	26.720	27.573
1914....	26.553	26.573	26.788	26.958	26.704	25.948	25.219	25.979	24.260	23.199	22.703	22.900	25.313
1915....	22.731	22.753	23.708	23.709	23.570	23.267	22.597	22.780	23.591	23.925	25.094	26.373	23.675

AVERAGE PRICE OF SILVER IN NEW YORK, 1865–1915
(In cents per fine ounce)

Year.		Year.		Year.		Year.		Year.	
1865.......	$1.337	1875...	$1.24	1885...	$1.07	1895...	$0.65	1905...	$0.61
1866.......	1.339	1876...	1.16	1886...	0.99	1896...	0.68	....	....
1867.......	1.33	1877...	1.20	1887...	0.98	1897...	0.60	....	....
1868.......	1.326	1878...	1.15	1888...	0.94	1898...	0.59	....	....
1869.......	1.325	1879...	1.12	1889...	0.94	1899...	0.60	....	....
1870.......	1.328	1880...	1.15	1890...	1.05	1900...	0.62	....	....
1871.......	1.325	1881...	1.13	1891...	0.99	1901...	0.60	....	....
1872.......	1.322	1882...	1.14	1892...	0.87	1902...	0.53	....	....
1873.......	1.297	1883...	1.11	1893...	0.78	1903...	0.54	....	....
1874.......	1.278	1884...	1.11	1894...	0.63	1904...	0.58	....	....

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1906....	65.288	66.108	64.597	64.765	66.976	65.394	65.105	65.949	67.927	69.523	70.813	69.050	66.791
1907....	68.673	68.835	67.579	65.462	65.981	67.090	68.144	68.745	67.792	62.435	58.677	54.565	65.327
1908....	55.678	56.000	55.365	54.505	52.795	53.663	53.115	51.683	51.720	51.431	49.647	48.769	52.864
1909....	51.750	51.472	50.468	51.428	52.905	52.538	51.043	51.125	51.440	50.923	50.703	52.226	51.502
1910....	52.375	51.534	51.454	53.221	53.870	53.462	54.150	52.912	53.295	55.490	55.635	54.428	53.486
1911....	53.795	52.222	52.745	53.325	53.308	53.043	52.630	52.171	52.440	53.340	55.719	54.905	53.304
1912....	56.260	59.043	58.375	59.207	60.880	61.290	60.654	61.606	63.078	63.471	62.792	63.365	60.835
1913....	62.938	61.646	57.870	59.490	60.361	58.990	58.721	59.293	60.640	60.793	58.995	57.760	57.791
1914....	57.572	57.502	58.067	58.519	58.175	56.471	54.678	54.344	53.290	50.654	49.082	49.375	54.811
1915....	48.855	48.477	50.241	50.250	49.915	49.034	47.519	47.163	48.680	49.385	51.714	54.971	49.684

The result of the purchase of between 4 and 5 million oz. for the United States Mint, before alluded to, and the frequent demand for other mints, was to raise the price by the end of September, notwithstanding that the Indian Bazaars abstained almost altogether from operating in this market, and China reduced its holding considerably on this side of the water. In October and succeeding months the almost continual pressure on account of English coinage imparted a very steady tone, while a certain scarcity of supplies became manifest, entailing a gradual advance in the price.

In the middle of November a careful investigation of the stock in London revealed that previous estimates had been placed too high. The ascertained total—only £750,000 ($3,600,000) in all—proved a great surprise to the East, and the Indian Bazaars, who had been inactive for many months, bought actively, and Chinese speculators were caught unawares. Buying for the usual coinage orders continued alongside the new competition, and the market got lively.

Within 7 working days, Nov. 20 to 27, the price jumped considerably. At these favorable rates the London stock was reduced further by sales on account of China, and the price became more effective as supplies became less. The rise was accompanied by a certain amount of speculative purchases by outside operators.

After the first week of December the market became somewhat depressed owing to China sales, and the price fell away. The English Mint bought heavily during a large part of the year, and acquired nearly 28,000,000 oz.

Apparent stocks of silver at the close of 1915 as closely as can be ascertained, together with the corresponding figures for the three preceding years are shown below:

	1915.	1914.	1913.	1912.
Shanghai	720,000	500,000	2,660,000	1,700,000
Bombay	6,900,000	5,000,000	1,320,000	12,000,000
At sea	3,125,000	1,500,000	2,000,000	5,700,000
London	6,800,000	11,000,000	15,800,000	15,000,000
Total, in oz	17,545,000	18,000,000	21,780,000	34,400,000

Sycee (60-oz. shoe-shaped bars) at Shanghai for the four periods were as follows:

	Ounces.
1915	62,100,000
1914	68,000,000
1913	50,300,000
1912	22,500,000

Imports and exports of bar silver at London were as follows:

Imports.	Ounces.	Exports.	Ounces.
U. S. and Mexico	80,062,000	British India	36,300,000
Canada	11,681,000	France	10,200,000
Spain and colonies	494,000	Holland and colonies	6,050,000
Australia	475,000	Russia	4,525,000
Other American states	270,000	Sweden	1,200,000
Egypt	238,000	Portugal and colonies	325,000
Other countries	129,000	Denmark	300,000
		Other countries	1,725,000
Total	93,349,000	Total	60,625,000

The future of silver is very difficult to foresee owing to unprecedented existing circumstances, and that may arise. There is no reason to think that the addition to silver coinage has been excessive, so much has gold been diverted from its ordinary functions.

It is not yet possible to give an accurate estimate of the silver production of the world in 1915. That of the United States showed an increase of about 2,500,000 ounces. In Mexico there was again a decrease, owing to the disturbed condition of the country and the interruption of mining operations. In Canada, also, there was a decrease, owing chiefly to the low price of silver that prevailed during a considerable part of the year, which induced the Cobalt producers to curtail their operations. Upon the whole it is probable that there will be a reduction of from 7 to 10 per cent. in the silver output of the world for 1915.

The following table gives the gold and silver production of the United States for 4 years, the figures for 1915 being the final statements made jointly by the United States Mint and the Geological Survey. According to this statement the gold production again showed an increase, the

SILVER PRODUCTION OF THE WORLD

Country.	1914.			1915.		
	Oz. Fine.	Kilo-grams.	Value (*d*).	Oz. Fine	Kilo-grams.	Value.
North America:						
United States	(*b*)72,455,100	2,253,657	$40,067,700	74,961,075	2,410,324	$37,397,300
Canada	(*a*)28,449,821	884,909	15,593,630	28,401,735	883,413	14,088,397
Mexico	(*b*)70,703,828	2,199,186	39,099,200	....	....	....
Central America	(*b*)2,416,888	75,174	1,336,500	....	....	....
South America:						
Argentina	(*c*)35,271	1,097	19,500	....	....	....
Bolivia and Chile	(*c*)4,049,856	125,968	2,239,600	....	....	....
Columbia	(*b*)351,311	10,927	194,300	....	....	....
Ecuador	(*c*)22,642	704	12,500	....	....	....
Peru	(*b*)8,351,563	259,769	4,618,400	....	....	....
Europe:						
Austria Hungary	(*c*)2,104,107	65,446	1,163,600	....	....	....
France	(*c*)520,766	16,198	288,000	....	....	....
Germany	(*c*)4,984,677	155,044	2,734,500	....	....	....
Greece	(*c*)803,750	25,000	444,500	....	....	....
Italy	(*a*)559,291	17,981	309,288	....	....	....
Norway	(*b*)247,194	8,230	136,700	....	....	....
Portugal	(*c*)205,822	6,402	113,800	....	....	....
Russia	(*c*)498,711	15,512	275,787	....	....	....
Spain	(*c*)4,231,815	131,527	2,340,200	....	....	....
Sweden	(*c*)58,969	1,834	32,600	....	....	....
Turkey	(*c*)1,509,133	46,940	834,600	....	....	....
United Kingdom	(*c*)128,543	3,998	71,100	....	....	....
Asia:						
British India	236,446	7,354	130,900	....	....	....
Dutch Indies	(*c*)465,980	14,498	257,700	....	....	....
Formosa	(*c*)51,763	1,610	28,600	....	....	....
Japan	(*c*)4,649,910	144,631	2,571,400	....	....	....
Africa	(*b*)1,028,857	31,990	570,000	....	....	....
Australasia	(*b*)3,520,274	109,494	1,946,700	....	....	....
Other countries	....	....	....	....	....	....
Total	(*b*)211,103,377	6,566,615	116,719,200	....	....	....

(*a*) Official statistics of the country. (*b*) United States Mint Report. (*c*) Estimated. (*d*) The value of silver unless specifically reported in the official statistics of the country is taken as $0.553 in 1914. (London quotations.) (*f*) Largely from imported ores and may duplicate production to some extent. (*g*) Exports.

total being $101,035,000, which is $6,503,900 more than in 1914. The gain is widely distributed, the principal increases being in California and in Colorado, those in the former state resulting from extended dredging operations chiefly, while in Colorado they were principally the result of better mill work and improved methods. California maintained its position as the leading gold producer, with Colorado rather a close second, Alaska third and Nevada fourth. A second group of large producers, although some way behind the first four, were South Dakota, which is a gold producer only, Montana, Arizona and Utah, where the gold is won chiefly in connection with copper and other metals. These eight states produced in all 94 per cent. of the total, the remaining 6 per cent. being scattered among 16 states, the more important of which were Oregon, New Mexico and Idaho. Of the insular possessions, the Philippines showed an increase of about 25 per cent. over 1914, which was chiefly due to extended dredging operations, while the output of Porto Rico was trifling. It should be noted that the dredging work in the Philippines is largely under the direction of Australian and New Zealand capitalists and engineers, a fact which is accounted for by the proximity of Australia to the Islands and the large degree of ignorance as to their resources, which still prevails at home.

The total silver production of the United States in 1915 was 74,961,075 fine oz., a decrease of 4,969,600 oz. from 1914. As is well known, the silver output of the United States is made chiefly in connection with other metals, largely copper, lead and gold, comparatively little being produced from mines whose chief value is in silver. The greatest losses in silver were in Idaho and Nevada, the other large silver-producing states very nearly holding their own. The four leading silver producers, in the order of their importance were Nevada, Montana, Utah and Idaho. A second group, some way behind the first, comprised Colorado, Arizona, California and New Mexico. No other state than the eight mentioned produced over 1,000,000 oz. of silver during the year 1915.

PRODUCTION OF GOLD IN THE UNITED STATES (*a*)

States.	1912.		1913.		1914.		1915.	
	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value. (*b*)
Alabama	855	$178,674	443	$9,200	495	$12,300	247	$5,100
Alaska	842,108	1,739,943	735,364	15,201,300	800,471	16,547,200	808,346	16,710,000
Arizona	159,890	3,303,504	198,406	4,101,400	221,020	4,568,900	220,392	4,555,900
California	967,443	19,988,486	979,174	20,241,300	1,028,061	21,251,900	1,090,731	22,547,400
Colorado	909,519	18,791,710	876,057	18,109,700	962,779	19,902,400	1,089,928	22,530,800
Georgia	478	9,881	645	13,300	813	16,800	1,684	34,800
Idaho	63,110	1,303,917	60,193	1,244,300	57,431	1,187,200	56,628	1,170,600
Montana	156,589	3,235,287	160,647	3,320,900	200,446	4,143,600	240,825	4,978,300
Nevada	645,253	13,331,680	579,408	11,977,400	558,064	11,536,200	574,874	11,883,700
New Mexico	29,280	604,961	43,149	892,000	58,974	1,219,100	70,632	1,460,100
North Carolina	6,910	142,760	5,574	115,200	6,303	130,300	8,258	170,700
Oregon	30,531	630,801	71,495	1,477,900	76,887	1,589,400	90,321	1,867,100
South Carolina	754	15,587	198	4,100	155	3,200	174	3,600
South Dakota	377,311	7,795,680	348,988	7,214,200	354,782	7,334,000	358,145	7,403,500
Tennessee	478	9,881	371	7,700	309	6,400	329	6,800
Texas	492	10,170	11	200	426	8,800	87	1,800
Utah	211,845	4,376,971	172,711	3,570,300	163,362	3,377,000	189,045	3,907,900
Virginia	424	8,755	11	200	15	300	24	500
Washington	13,796	285,044	31,806	657,500	28,435	587,800	22,330	461,600
Wyoming	1,108	22,884	847	17,500	324	6,700	672	13,900
Other States	15	310	32	700	10	200	......	....
Total	4,418,139	$91,284,886	4,265,530	$88,176,300	4,519,662	$94,429,700	4,825,311	$99,748,000
Porto Rico	....	....	50	1,100	135	2,800	34	700
Philippine Islands	19,372	400,248	34,204	707,000	53,179	1,099,300	63,898	1,320,900
Total	4,437,561	$91,685,134	4,299,784	$88,884,400	4,572,976	$94,531,800	4,887,604	$101,035,700

(*a*) The statistics in this table are reported by the Director of the Mint, those for 1915 being the preliminary figures (subject to revision). (*b*) At $20.67 per oz.

SILVER PRODUCTION OF THE UNITED STATES (*a*)

	1914.		1915.	
	Fine Ounces.	Value. (*b*)	Fine Ounces.	Value. (*c*)
Alabama	300	$150	....	....
Alaska	865,900	478,800	1,054,634	$526,100
Arizona	4,439,500	2,455,000	5,665,672	2,826,500
California	2,020,800	1,117,500	1,689,924	843,100
Colorado	8,804,400	4,868,800	7,199,745	3,591,900
Georgia	100	50	141	100
Idaho	12,573,800	6,953,300	13,042,466	6,506,800
Illinois	1,900	1,200	3,892	1,900
Maryland	100	50	....	....
Michigan	415,500	229,800	581,874	290,300
Missouri	60,000	33,200	55,534	27,700
Montana	12,536,700	6,932,800	14,423,173	7,195,600
Nevada	15,877,200	8,780,100	14,453,085	7,210,500
New Mexico	1,771,300	979,500	2,337,064	1,165,900
North Carolina	1,500	800	1,496	700
Oklahoma	6,200	3,400	....	....
Oregon	147,400	81,500	125,499	62,600
Philippine Islands	10,300	5,700	15,148	7,600
South Dakota	179,800	99,400	197,569	98,600
Tennessee	102,800	56,800	99,171	49,500
Texas	574,700	317,800	724,580	361,500
Utah	11,722,000	6,482,300	13,073,471	6,522,200
Virginia	1,500	800	(*d*) 150	100
Washington	341,300	188,700	213,877	106,700
Wyoming	100	50	2,910	1,400
Total	72,455,100	$40,067,400	74,961,075	$37,397,300

(*a*) Figures of the Bureau of the Mint and the U. S. Geological Survey, those for 1915 being a preliminary estimate. (*b*) At $0.553 per oz. (*c*) At $0.499 per oz. (*d*) Vermont; Virginia, *nil*.

Gold and Silver Mining in the United States

By M. W. von Bernewitz

Introduction.—The increase in value of the principal metals in 1915 is estimated at $250,000,000 above that of 1914, due, of course, to abnormal causes, to which gain gold contributed $5,000,000, while silver declined 5,000,000 oz. or $2,500,000. The totals for the precious metals are given by the Bureau of the Mint and Geological Survey as $101,035,700 and 74,961,075 oz. respectively. Increased activity in gold and silver mining was reported from all over the country, and capital being easier to procure, many old properties were re-opened. Their yields will be noticeable in the returns for 1916. The search for and extraction of the base and rarer minerals somewhat militated against keen prospecting for the precious metals. A factor that should be felt considerably is the tremendous advance of flotation processes in most States, and by the much higher extraction of copper, lead, and zinc ores containing gold and silver, the production of the precious metals will be largely augmented. A review of the most important events in the various states follows:

Alaska.—Of the total increase of approximately $6,500,000 in gold production in the United States and its territories during 1915, Alaska contributed $200,000. The yield of the Territory was nearly $17,000,-

000, making a total of $261,000,000 since 1880. Silver, a by-product from gold and copper recovery, increased $47,000 to $526,000. Generally speaking the region was more active than before, and there was little to hamper steady operations, such as water shortage, storms, etc. Lode mining in the Juneau district yielded considerably to the year's increase of gold. Completion of the Government railway from Seward to Fairbanks will stimulate production within 2 years.

Lode Mining.—While a fair amount of gold-lode mining is done in the Fairbanks, Kuskokwim, and Nome districts, Juneau is the most important. On Douglas island, opposite Juneau across the Gastineau channel, the Alaska Mexican, Alaska Treadwell, and Alaska United Cos. continued their extensive development down to 2400 ft., construction, and gold production. The crushing capacities were enlarged, and experiments made for further improvements in reduction methods. There are now 960 stamps crushing ore in the group. The output in 1915 was as follows:

	Mexican.	Treadwell.	United.
Tons	216,428	900,211	533,419
Bullion	$379,797	$1,828,724	$1,042,175
Profit	99,477	859,187	367,250
Dividends	90,000	650,000	252,280

Although the grade is gradually decreasing, yet a good future is assured for these mines. One or two other properties on the island are being financed for resumption of work.

On the mainland, all around Juneau, important work was done. Foremost is that of the Alaska Gastineau Co., the operating company for the Alaska Gold Mines, which commenced gold production early in the year. Its Perseverance mine was well developed, and was supplying the mill with nearly 6000 tons of ore daily, when an intrusion in the shape of a "horse" of schist affected the grade, resulting in a temporary reduction in the quantity milled. Yet work is on a large scale, as in January, 1916, there was treated 119,914 tons of $1.37 ore, with 80 per cent. recovery. The residue is worth only 20 cts. per ton. All costs are 65 cts. per ton. Very cheap power is generated at the Salmon Creek and Annex hydroelectric plants. Later on in 1916 the mill will have a capacity of 10,000 tons per day; eventually this will be 20,000 tons. Treatment consists of jaw and gyratory crushers, dry-crushing rolls, concentrators and tube mills. Concentrate is shipped to smelters. The enterprise has been criticized[1] from a financial standpoint; at the same time it is a meretorious proposition. The mine and mill were described by Robert S. Lewis[2] in an interesting way.

[1] *Min. Sci. Press*, Nov. 20, and Dec. 18, 1915.
[2] *Min. Sci. Press*, Sept. 11, 1915.

The Alaska Juneau Mining Co. was financed during the year, the mine continuously developed, and in December contracts were let for machinery amounting to $458,864. This is part of the equipment to handle a minimum of 8000 tons of ore per day. Electric locomotives are to haul ore from mine to mill. The latter will include jaw and gyratory crushers, ball mills, and concentrators. The company's small stamp mill operated during the year.

Judging by the exploration done at the Alaska Gold Belt, Alaska Ebner, Alaska Taku, and Alaska Treasure Cos., and equipment proposed by the first-named, and possibly by the second, the current year or early in 1917 should see additional gold producers on the list.

A fair number of lode mines were productive in the Ketchikan, Berners Bay, Prince William Sound, and Willow Creek districts, including the Dutton, Jualin, Granite, and Cliff mines. The 12 lode mines operated in southeastern Alaska in 1915 yielded over $5,000,000. Both the Prince William Sound and Ketchikan areas are considered worthy of more exploration.

The new railroad will render accessible the lode and placer mines of the Kenai Peninsula, Valdez Creek, Willow Creek, and Yentna districts, which yielded $500,000 in 1915, an increase.

After a great deal of underground work had been done during several years and a number of stamp mills erected and operated, quartz mining at Fairbanks made little progress. The high cost of supplies has militated against profits and the owners are now awaiting completion of the railroad from Seward. It is proposed to bring in coal from the Matanuska field for a central power plant. The gold recovered in mills last year was $250,000.

According to Alfred H. Brooks of the U. S. Geological Survey, there were 23 producing gold-lode mines in Alaska in 1915, a decrease of five, yielding $6,200,000, an increase of $1,400,000.

Placer Mining.—Hydraulicking, washing by various means, and 42 dredges recovered $10,500,000, a small decrease. Of these boats, 37 are in the Seward Peninsula, tributary to Nome, where the falling-off is probably of a temporary nature. All dredges produced under $2,000,000, against $2,350,000 in 1914. Two boats operated near Iditarod.

The new railway will stimulate placer work at Valdez Creek and Yetna. At the former is the extensive property of the Valdez Creek mines, a Boston concern, which has spent $125,000 this year for new plant. In the season of 100 days, a profit of up to $300,000 is expected from $1 gravel.

There was no expansion of gravel mining at Fairbanks, the main creeks supplying most of the gold, which totaled $2,450,000, from 115 properties employing 1200 men. A promising area is that at Tolovana, 50 miles northwest of Fairbanks. A good deal of prospecting was done, and reliable reports indicate that the ground will be a fair producer. Better roads are needed for thorough development.

Iditarod, where 31 mines and two dredges were operated, yielded over $2,000,000.

In the Seward Peninsula, dredges, open-cut workings, hydraulicking, beach-mining, and deep-mining recovered a total of $2,900,000, an increase of $200,000. When thawing apparatus is added to the gravel, the dredges will show up better. Underground mining near Nome was much more active in the winter than previously.

At the Circle, Hot Springs, Innoko, Koyukuk, and other Yukon districts, the usual work and production was made. The much-talked-of Chisana area shows a 50 per cent. decrease, to $135,000.

Literature published during 1915 dealing with Alaska included "Mineral Resources of Alaska," "Geology and Mineral Resources of Kenai Peninsula," "The Broad Pass Region," "The Ellamar District," and "The Willow Creek District," bulletins by members of the Geological Survey; and several interesting articles on the mines and mills around Juneau, and the lode-mining situation at Fairbanks are to be found in the technical press.

Arizona.—In spite of the large increases in base metals in this State, which yield gold and silver as a by-product, and the general revival in prospecting and development of gold mines, the output in 1915 gained only 1 per cent. over the $4,568,900 in 1914. However, considerably more gold will be extracted in 1916, on account of the publicity campaign of the State Bureau of Mines at Tucson attracting much attention to possibilities, and results of a great deal of work under way in the Oatman district of Mohave County.

A boom set in at this center early in the year, influential capital became interested, many companies were organized, and genuine development commenced. Some ridiculous statements were made in the daily press as to the reserves of the area, but later on boom-talk subsided, letting the reliable information take its place. Oatman is 20 miles northeast of Needles, just over the border in California, from where it is reached by auto. For some years the Tom Reed and Gold Road mines at Oatman had been producing $100,000 and $80,000 per month respectively. During its financial year ended Mar. 31, 1915, the Tom Reed Gold Mines Co. produced $1,002,407 from 46,995 tons of ore. Costs totaled $9.213 per ton, mining being $4.897; treatment, $3.327; marketing, $0.145; and depreciation on all departments, $0.844. The recovery was 96.2 per cent. Dividends were $554,829. Development amounted to 4865 ft. down to

1075 ft. Ore reserves broken and blocked were 30,000 tons in addition to a year's supply for the mill in other sections of the mine. At a depth of 460 ft. and 565 ft. in the United Eastern, the Tom Reed vein was cut, showing wide shoots of good ore. This started a revival of the district, and over 50 companies were formed to explore within a radius of 4 miles. Gold is seldom found near the surface here in payable quantities. Deep sinking, at least 500 ft., is necessary, and many shafts are on their way

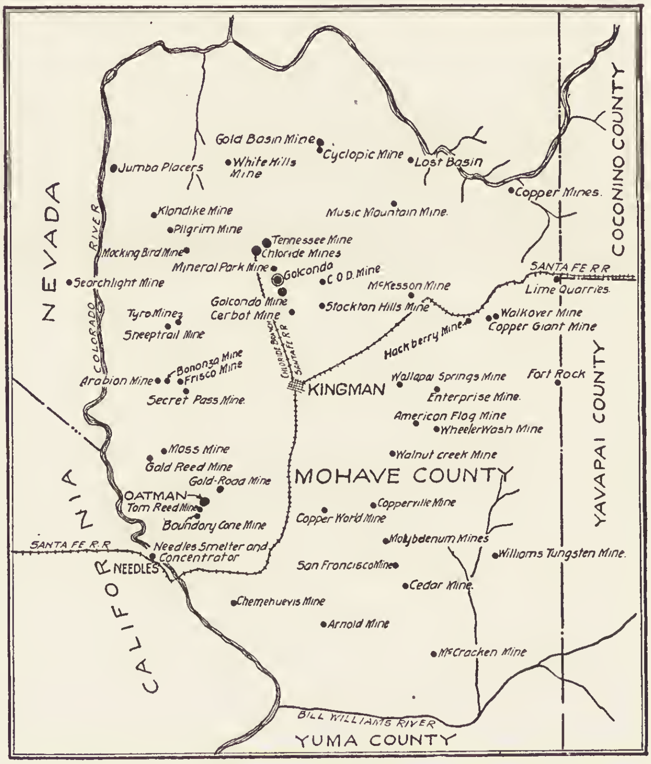


Fig. 1.—Mohave County, Arizona, showing principal mines, and the gold center of Oatman.

to this point. The mines are dry, and the ore oxidized to considerable depth. The veins occur in andesite. The problem, according to Howard D. Smith, in the *Mining and Scientific Press*, is not so much the finding of veins, as the discovery of ore-shoots in them. A 200-ton mill is being erected at the United Eastern. Other plants are contemplated, and the next issue of this volume should have some interesting features to record from Mohave County.

Placer deposits in Arizona are receiving more attention of late. They occur in several counties, especially in Yavapai and Yuma. If plenty of water were available, there is no doubt that the gravels would be profitable, as past production is considerable.

The State's output of silver increased 27 per cent., from 4,439,500 to 5,665,672 oz. Most of this is from copper and lead ores. The Commonwealth mine in Cochise County treats nearly 10,000 tons of ore monthly, mostly silver-bearing. The old Tombstone mine, now the Bunker Hill, also treated silver ore. Steady development has been done at this property, and larger yields will be recorded this year.

It is possible that the search for the rarer minerals, such as antimony, tungsten, and molybdenum, may temporarily affect the precious-metal discoveries in Arizona, as the former are more attractive by their present high prices. Arizona is essentially a base-metal producer, the gold and silver yield being under 10 per cent. of that of copper, lead and zinc. While less than 400,000 tons of ore is treated direct for the precious metals, over 5,500,000 tons is concentrated, and over 2,000,000 tons smelted direct for base metals, which give the bulk of the gold and silver. Such properties as the Arizona Copper, Calumet & Arizona, Copper Queen, Detroit, Inspiration, Miami, Ray, Shannon, and United Verde, great copper producers, largely augmented the gold output.

The many samples that are being sent to the Bureau of Mines for determination prove that the prospectors of the State are busy, and from the determinations of these samples they are finding something. Of course this does not refer to gold alone.

California.—This State contributes almost 25 per cent. of the gold, and 2 per cent. of the silver output of the Union, the figures for 1915 being $22,547,400 and 1,689,924 oz. respectively, the former an increase of $2,000,000, and the latter a decrease. According to Charles G. Yale of the U. S. Geological Survey, the yield last year was the largest in 32 years and with one exception, the largest in 51 years. There are about 700 producing metal mines in the State, about evenly divided between deep and placer mines. About 2,500,000 tons of ore is mined and treated annually of an average value in all metals of $6.75 per ton. Fully 2,000,000 tons of this is treated direct in gold and silver mills, yielding 85 per cent. by amalgamation, concentration, and cyanidation. In value of all metals produced, Shasta is the leading county, while in value of gold output, Nevada, Amador, Yuba, and Sacramento are the leading counties in the order named. The first two are deep-mining, the others dredging.

There has been a distinct revival in all kinds of metal mining in the State in 1915, particularly in gold mining. Dredge men have begun operations on tracts formerly considered too small for this class of work, and numerous quartz mines have been re-opened, while the older ones have been deepened with good results.

In Amador County, mining continued in the vicinity of Jackson, down to 3800 ft. vertical. Encouraging developments were reported from the Argonaut and Kennedy. During the 6 months ended Dec. 31, 1915, the Keystone Co. at Amador City produced $86,167 from 38,663 tons of ore, equal to $2.23 per ton. The 40-stamp mill lost only about 5½ days

Fig. 2.—The above map includes the most important gold-producing centers of California, including those places mentioned where a revival is of importance.

during the period. Most of the ore came from a depth of 900, 1000, and 1200 ft. Work at 1400 ft. is highly encouraging. The old Zeila is being re-opened. The Plymouth, 12 miles away, regularly reported its monthly yields, an average one being 10,350 tons for $57,000 of gold, of which $22,500 is profit. One or two other companies are commencing to make their yields public, but it is a pity that the others consider it necessary to be secretive about the subject. For some years there have been reported sales of the old Eureka mine at Sutter Creek, owned by Mrs. Hetty Green, but closed for over 30 years, yet nothing came of these rumors. Although this review deals with 1915, it is important to state that at last the property has been sold to Californians and Eastern people, the transaction being completed in February, 1916. The Consolidated Amador Mining Co. has commenced unwatering, will erect new hoisting machinery, etc., will re-timber and clean out old workings, and resume development. It is to be hoped that the Eureka will turn out to be another Plymouth, which also was closed over 20 years. The Mother Lode region is much pleased with this new work.

Butte County is best known for its dredging, drift, and small lode mines. The Forbestown district has received some attention as a deep-mining center, but it is considered that a consolidation of properties is wanted. More work was done in the Magalia drift-mines, but there is a want of interest in these deposits which have produced so much, and require strong capital for their exploration. As a center for dredging, Oroville is getting of less importance each year. There are now only nine boats digging, compared with three times as many a few years ago. One profitable dredge was burned last year, while another was removed to Siskiyou County. A boat has been arranged for digging and treating tailings.

In Calaveras County, on the Mother Lode, are close to 50 producing mines, treating over 400,000 tons of ore. Little of special note was recorded from the old districts. Another dredge started on the Mokelumne River by the Oro Co. Those at Jenny Lind continued. By resumption at the Calaveras copper mine, the gold output will be enlarged. The Penn copper mine at Campo Seco contributes gold and silver to the total. The old Royal mine at Hodson resumed production, and is treating 140 tons daily. Treatment is to be improved by flotation.

In Eldorado County there was a revival last year, especially adjacent to Placerville. Some drift-gravel mines were re-opened.

Over $3,500,000 is produced by 40 or more Nevada County mines, but most of it from the Brunswick, Empire, Golden Center, North Star, and Union Hill mines. The companies operating these worked to a depth of 6200 ft. on the incline, generally with good results. New shaft equipment was erected, mills improved, and employees' conditions bettered. During the year ended Dec. 31, 1915, the Brunswick Consolidated Gold Mining Co. at Grass Valley, produced $233,557 from 22,004 tons of ore, with a profit of $37,750. The average value was $11.113 per ton, and recovery $10.088. Three dividends, of 6 cts. per share each, absorbed $71,152, the balance coming from the previous year. Development amounted to 2905 ft., down to 1100 ft. Reserves are estimated at

16,000 tons ready to be stoped, and a considerable quantity indicated, but not opened. The formations in this mine are very puzzling. All expenses were $8.5925 per ton. This company gives copious information in its reports. A new mill commenced work in October. Average recovery was 90.8 per cent.

The threatened apex suit between the North Star and Empire Cos. was settled amicably in February, 1916. Regular dividends were paid. The Empire Co. has paid the full amount of its purchase price of $500,000 for the Pennsylvania mine. Some placer mining was done at You Bet and other centers.

Twenty miles from Sacramento are the gravel deposits of the Natomas Co. of California. While the yardage moved in 1915 has not been published, the gold output from 10 dredges was worth $2,416,960 gross, and $1,675,076 net. Incidentally the company made $159,308 net from selling crushed rock from tailing-piles. One boat has been fitted for leveling and re-soiling the land, tests being started early in 1916.

Shasta County is a base-metal region, its copper mines yielding 5 per cent. of the gold and 30 per cent. of the silver of the State, yet there are a number of interesting gold mines with their own reduction plants. From these some good developments were recorded. Large areas of gravel near Redding are to be dredged.

Adits, shafts, placers, and drift-mines at the well-known properties of Sierra County were actively worked in the Alleghany, Downieville, and Sierra City areas.

Dredging and small-scale mining continued in Siskiyou County.

Trinity County is best known for its hydraulic mines and dredges, the chief of the former being Lagrange and Trinity Gold, and of the latter, the Alta Bert and Trinity Dredging. The Lagrange operates four 8-in. giants, and moves about 4,000,000 cu. yd. per year. The Globe Consolidated quartz mine and mill near Dedrick were acquired by the Crown Reserve Co. of Cobalt, Ont.

Additional interest was taken in Tuolumne County mines during the latter part of 1915, particularly around Sonora. The Dutch, App, and Sweeney mines were acquired by new capital, which is to thoroughly explore and equip them. The Pittsburg Silver Peak Co. of Nevada is examining the Rawhide under option.

Yuba County is noted for its great dredges working along the Yuba River. The Yuba Consolidated is erecting another 16-cu. ft. boat, so is the Marysville Co., so during 1916 there will be about 14 dredges at work.

Placer mining for gold, for years considered a decadent industry in California, has for the past 18 years been growing in importance, until now the placer mines are producing 44 per cent. of the total gold yield.

This condition has been entirely brought about by the dredging operations, the gold dredges now producing some 86 per cent. of the placer gold. During 1915 there were 67 boats in California, of which six were closed down all or part of the time, and one was burned, leaving 60 active dredges. The present tendency is toward extensive yardage in dredging operations, so the new machines are much larger and more powerful than those built formerly. It is considered probable that for this reason the yield of dredge-gold in California will continue about the same for some years, even though the old and smaller machines discontinue operations.

The San Francisco Mint received a total of $51,577,823.99 in gold in 1915 from the United States and Alaska, and $68,291,685.68 from foreign sources. Coinage from the opening of the institution totals $2,000,591,286.87.

Colorado.—The future of the State's mining looks to the diversity of mineral output rather than to great increases in gold and silver, according to G. J. Bancroft in the *Mining and Scientific Press.* For many years, Colorado was famed chiefly for its production of the precious metals. It is possible that the gold and silver product of the State will soon be a matter of relative secondary importance; furthermore, the metalliferous mining will be secondary to the non-metalliferous mining. Colorado has been known as the leading bi-metallic State; it is now the leading multi-metallic State, and will probably soon become one of the leading multi-mineral States. However, Colorado is second as a gold-producing State, and should keep its place. In 1915 the mineral production of Colorado increased $10,000,000 to $43,000,000, gold gaining $2,500,000 to $22,530,800, while silver dropped 1,600,000 oz. to 7,199,745 oz. Of about 2,800,000 tons of mixed ores treated in the State, nearly 40 per cent. is smelted, which yields a considerable amount of the precious metals as by-products. If concentrate from all mills is included, the smelters produce 50 per cent. of the gold and 90 per cent. of the silver. Gold and silver ore treated direct for its content, must have totaled at least 2,200,000 tons last year. The Durango, Globe, Leadville, Pueblo, and Salida smelters treated about the same as in 1914.

The principal gold-producing counties are Chaffee, Clear Creek, Gilpin, Lake, Ouray, San Juan, Summit, and Teller. The first-named had a decrease, the total gold being $322,000 and that of silver 235,000 oz. Development and milling in Clear Creek was very active, the samplers' capacity being fully taxed. Gold and silver increased slightly to $547,000 and 376,000 oz., respectively. New companies were organized, old mines re-opened, and mills overhauled in Gilpin County, resulting in a busy year, yielding $559,000 gold and 130,000 oz. silver. The revival in Lake, Russell, and Willis gulches near Central City and Black Hawk was notable. The U. S. Geological Survey issued a useful bulletin on the ore deposits of the county. Lake County, in which is Leadville, is the greatest lead-zinc-silver-gold region. The silver output, 2,700,000 oz., a decrease, is a by-product; the gold, $2,400,000, a good increase, is partly so, but some small mines produced very rich ore. Of great probable importance to the district is the unwatering and re-opening of the Down Town, Fryer Hill, and Carbonate Hill areas for base metals, and silver. An interesting event was the starting of the Derry Ranch Gold Dredging Co.'s boat, 12 miles south of Leadville in the Arkansas valley. In the last 2 months of 1915, the gold recovered was $69,291 from 128,000 cu. yd. of gravel, at a cost of 5 cts. per yd. The ground contains boulders, and is somewhat difficult to dig. Summit County was busier than usual, due to metal prices. Dredging around Breckenridge continued, the Tonopah Placers Co. which made $91,000 net in the last quarter of 1915, operating three boats, and the French Gulch Co. one boat. In mid-winter only one dredge, that of the former company, can work. Ouray County had small decreases in gold and silver outputs. There are a number of good mines and mills in scattered areas. Of importance is the low-level adit being driven 10,700 ft. by the Camp Bird Co. to cut its lode 450 ft. deeper than any existing workings, and 800 ft. below the main ore-bearing ground. Other ore-bodies may be cut during this work. The opinion used to prevail in the San Juan region that the gold-silver veins became impoverished as they passed out of the andesite breccia into the underlying sedimentary rocks. In that part of Colorado a great thickness—10,000 ft. at its maximum—of lava-flows and breccias lie upon the sedimentary series, the highest member of which is a Tertiary conglomerate, next to which come the limestone and sandstone beds of the Jurassic and Triassic. While some productive mines have been developed along lodes enclosed within the sedimentary rocks, it has been proved by experience that the much richer veins in the great covering of breccia do not continue into the sedimentary terrain, and become impoverished before they reach that horizon. The lower adit of the Camp Bird is fully 2000 ft. above the conglomerate, so that there is an ample margin of safety, say, 1000 ft., between this low-level adit and the limit of possible productivity, according to T. A. Rickard, in the *Mining and Scientific Press*. A number of veins should be intersected and a large territory prospected without great cost, having regard to the value of the ore-bodies already exploited in the existing upper workings. During the year ended June 30, 1915, the Camp Bird produced $952,288 from 32,313 tons of ore, an increase of $151,209. The recovery was 94.31 per cent. Of the total value, amalgamation gave 58.48 per cent., concentration, 36.59 per cent., and cyanidation, 4.93 per cent. The mine profit was $583,700. Estimated profit in reserves is $275,000. $480,000 was paid in dividends. From Apr. 30, 1903, to June 30, 1915, the total output was 795,129 tons yielding $22,100,000, with a profit of $13,830,000. During the last quarter of 1915, the profit from 7897 tons, yielding $235,451 was $135,000.

In San Miguel County there were slight decreases in precious metals from the $2,115,000 and 1,280,000 oz. in 1914. The Liberty Bell, Smuggler Union, and Tomboy were the principal producers. Each has a large stamp mill, concentration, and cyanide plant. In the year ended June 30, 1915, the Tomboy Gold Mines Co.'s revenue from 145,857 tons of ore, etc., was $1,050,870. Costs totaled $4.49 per ton, leaving a surplus of $396,223. Two dividends amounted to $221,000. Ore reserves in its Argentine and Montana mines were 185,000 and 350,000 tons respectively.

Teller County is the principal gold-producing center of the State, in fact, of the United States. According to *The Cripple Creek Times*, the total production in 1915 was $16,189,727 from 982,897 tons of ore. The largest month was March, with $1,986,493 from 76,618 tons, when the Cresson mine shipped so much rich ore from the shoot at 1200 ft. (Its output last year was $1,983,200 from 60,000 tons of ore.) The Cripple Creek district has produced $354,764,653 to date.

The approximate outputs last year were as follows:

Mills.	Tons.	Value.
Golden Cycle (own mine and custom ore)	407,950	$9,179,650
Portland (Cripple Creek)	211,415	642,179
Portland (Colorado Springs)	128,000	2,600,000
Portland (Stratton's)	66,700	155,284
Stratton's Independence	55,256	169,755
Colburn-Ajax	15,235	105,577
Gaylord	9,700	26,700
Neville-Free Coinage	8,152	28,228
Kavanaugh-Jo Dandy	6,800	13,600
Wild Horse	3,730	15,105
Isabella	1,500	3,000
Caley	4,917	19,064
Smelters	52,692	2,944,250

Dividends paid by listed corporations were as follows: Golden Cycle Mining Co., $3,495,000; Portland Gold Mining Co., $360,000; Vindicator Consolidated Gold Mining Co., $225,000; Elkton Consolidated Mining & Milling Co., $50,000; El Paso Consolidated Gold Mining Co., $50,000; and Mary McKinney Mining Co., $26,185; a total of $4,206,-185. Dividends of close corporations were as follows: Cresson Consolidated Mining & Milling Co., $1,000,000; Stratton's Cripple Creek, Ltd. (sale of property, estimated), $500,000; Strong Gold Mining Co. (estimated), $250,000; Stratton's Cripple Creek Mining & Development Co., the Stratton Estate (estimated), $50,000; and Gold King Mining Co., $10,000; a total of $1,810,000. Profits of leasing companies and lessees, closely estimated, were $500,000, making a grand total of dividends and lease profits of $6,516,185.

In 10 months, the Roosevelt drainage tunnel was extended 1920 ft.; since Aug. 1, the monthly rate has been 300 ft. The heading is close to the Elkton main shaft. Fifty-two men are employed. The total subsidence of water was 149 ft. The total water discharged last year was

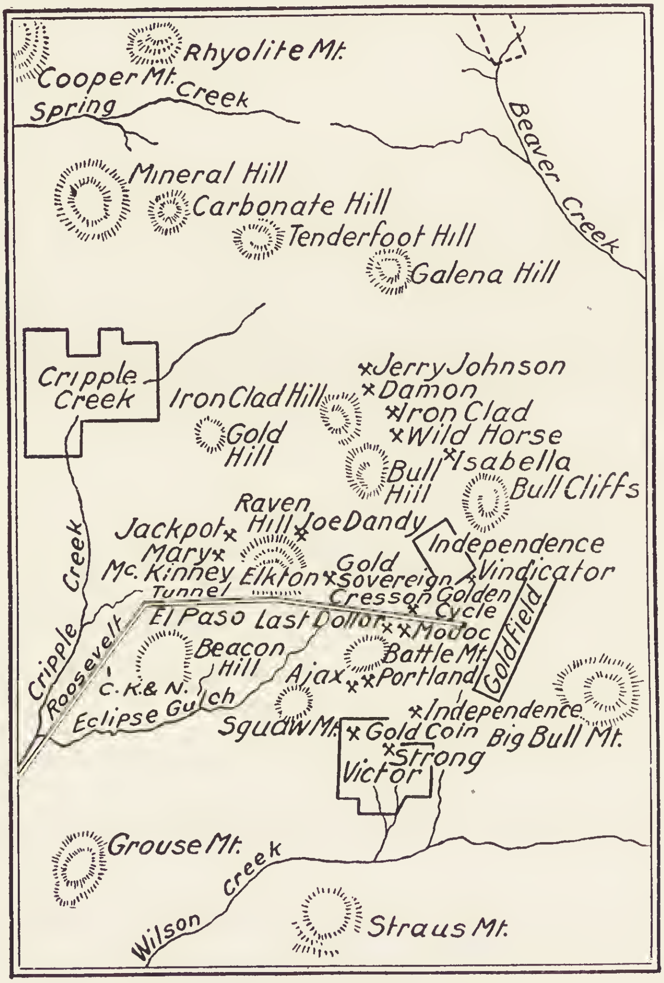


Fig. 3.—Plan of Cripple Creek District.

5,550,000,000 gal., equal to 37,000,000 gal. per vertical ft., according to the engineer in charge, T. R. Countryman. The water has a temperature of 70° F. The tunnel and area to be drained was described by T. H. Sheldon.[1]

There are now four producing mines on the recently opened Tender-

[1] *Eng. Min. Jour.*, Oct. 2, 1915.

foot Hill, with good prospects. Leasing was done more than ever, these operators being of considerable importance to the district.

The report of the Vindicator Consolidated Gold Mining Co. for 1915 is of considerable interest. An important transaction was completed in March, whereby the company purchased the mining property of the Golden Cycle Mining Co., of 43.5 acres, adjoining Vindicator ground, which now totals 130 acres, for $1,300,000. The assay, mine office, and engineering staffs were consolidated, also the air-compressing plants, while the machine shops, boiler plants, etc., will be, resulting in reduction of charges. Improvements at the ore-house enabled an average of 10,527 tons of ore to be handled monthly against 6358 tons before. Early in 1915 the new concentrating-plant, to handle reject from the ore-house and make a shipping product, was at full capacity; it is a complete success, treating 250 tons per 8-hr. shift. Concentration is 11 to 1; the recovery from $2 ore was 55 per cent. Profits from this plant are double what was expected from tests. Development and stoping continued with uniformly satisfactory results. Stoping on the large ore-bodies at 1600 ft. was vigorously prosecuted. The middle vein at this depth is 400 ft. long and 35 ft. wide. It is in ground previously regarded as barren. So far at 1500 ft. this lode is 225 ft. long of good value.

The Golden Cycle shaft was sunk from Nos. 18 to 20 level, a depth of 2210 ft. The principal ore-body, the Ready Money, was cut on No. 18 in April. On this level it is larger than on No. 17, but not so wide or high in grade. Since acquiring this mine the company has done a great deal of exploratory work. Lessees in both mines have done several thousand feet of development. The extension of the Roosevelt drainage tunnel will cut the Golden Cycle shaft 65 ft. below No. 18 level. This will relieve the pumps at Nos. 18 and 20. A heading will be started from No. 20 to meet the drainage tunnel. Pumping cost $41,273 last year.

Twelve months at the Vindicator and 10 months at the Golden Cycle resulted as follows: crude ore extracted, 218,487 tons; shipping ore from this, 125,397 tons; average gold-content, $23.73 per ton; company's share (76,209 tons) worth $2,164,669; and lessees' share (49,188 tons), worth $815,183; a total of $2,979,852. Freight and treatment (company) cost $446,647; gross proceeds for company were $1,718,022; and net royalties from leasing, $251,624; making a total revenue at the mine of $1,969,646. The total profit was $1,350,164. Dividends paid amounted to $225,000. Cash on Jan. 1, 1916, was $286,495.

Not less than 2,000,000 tons of $2 ore remains on the dumps, also large blocks of low-grade material in the mine, all profitable if a process for treatment can be devised. Since July, 1915, two metallurgists have been experimenting with flotation and cyanidation. A 10-ton flotation plant is in operation. The tests resulted in the recommendation that the old Golden Cycle plant at the mine be remodeled into a 300-ton flotation plant, sufficient to treat all the reject material from the Golden Cycle ore-house, as well as to experiment on all grades of ores. A recovery of 90 per cent. at a cost of less than $1 per ton is expected. Later a 1000-ton mill will be erected.

Workmen's compensation, a new law, has been carefully studied, and additional benefits were offered and accepted by the employees.

During 1915 the Portland Gold Mining Co. reported that Stratton's Independence mine was purchased for $325,000. To the end of 1915 the combined properties of over 250 acres had yielded $64,426,370 from 3,653,969 tons of ore. Adjacent to these workings, and on dumps there is from 12,000,000 to 15,000,000 tons of profitable low-grade ore. This will be treated on a large scale by flotation, at less cost and with higher recovery than by cyanidation. The Independence mill has been partly remodeled for this process, and is to be enlarged to 1000 tons' daily capacity. The Victor plant is also to be changed and enlarged. That at Colorado Springs, treating high-grade ore, will continue to use cyanide. Every level of the Portland mine contributed to last year's output. Lessees worked only at 200 ft.

Development in the mines amounted to 19,808 ft., an increase of 4216 ft., each foot opening 3.6 tons of ore. Thirty-five new stopes were opened. No. 2 shaft was sunk 154 ft. to 1870 ft. depth. Indications here point to a large amount of good ore. No. 17 level has been an unusually productive one.

From the Portland mine the Colorado Springs mill treated 55,339 tons of $24.6854 ore, 213,122 tons of $3.033 ore at Victor, and 12,067 tons of $22.75 ore by lessees, a total of 280,528 tons averaging $8.154 per ton. Including the Independence there was treated 426,586 tons. The net profit was $798,460. Dividends amounted to $260,000, making $10,177,-080 to date. The cash balance on Jan. 1, 1916 was $483,503.

Idaho.—With commendable promptitude the State inspector of mines, Robert N. Bell, has prepared and issued a 134-page report on the mining industry of Idaho for 1915. The total of all metals was nearly $40,000,-000, an increase of over $14,000,000; but the gold and silver yield decreased from 57,431 oz. and 12,573,800 oz. to 56,628 oz. and 13,042,406 oz. respectively. The high prices of copper, lead, and zinc, and the search for antimony and tungsten ores probably diverted attention from the precious metals. Dividends of $9,000,000 were paid by base-metal producers. The past year was the most prosperous in the history of the State. An average of 6500 men was employed at all mines.

About 50 per cent. of the gold output came from Boise County from placer and deep-mining operations. The largest producer was the great dredge of the Boston-Idaho Co., near Idaho City. This is said to be the cheapest operated, and handles the largest yardage of any dredge in the United States. What might be an important gold producer is the new area on the northern border of Boise basin, near Grimes Pass. With the lead, zinc, and copper ore are gold veins of gold and silver. In Elmore County there was a revival in the Atlanta district. Some rich gold ore was shipped from the Allie mine in Lemhi County. The Snake River gravels were worked to some extent, but most of them of too low grade, while the gold is so fine as to be very difficult to save. The U. S. Geological Survey issued a bulletin on the subject. Some placer ground in several counties is to be worked this year. All counties produced gold, ranging from 9 oz. in Power, to 7500 oz. in Lemhi, exclusive of Boise mentioned.

Of the silver, 12,200,000 oz. came from Shoshone County, the producer of 95 per cent. of the State's lead, zinc, and silver; and 190,000 oz. from Custer, and 253,000 oz. from Lemhi County. The silver generally was produced as a by-product, therefore there is little comment to make on its extraction.

Michigan.—The amount of silver recovered from the electrolytic refining of copper, especially at the Calumet & Hecla plant at Hubbell, is increasing and of importance. The deeper workings of the conglomerate lode contain more silver than in the upper ones. The 1915 production amounted to 581,874 oz.

Montana.—The value, $87,000,000, of all metals produced in this State, in 1915, was an increase of 81 per cent. over the previous year. Gold rose from $4,143,600 to nearly $5,000,000. While this is partly due to more activity in gold mining, the great increase of copper helped swell the gold yield. Normally, about 15 per cent. comes from this source, the great mines in the Butte district of Silverbow County. Placers produce 25 per cent. and last year there was a larger yield from dredging in Alder gulch, Madison County, which recovers most of the placer gold, although Granite, Missoula, and Powell County gravels contribute a fair amount. The Conrey Placer Mining Co., according to Hennen Jennings in the *Mining and Scientific Press* has four dredges at work. One has 16-cu. ft. buckets, a 550-hp. digging motor, a 100-ton washing trommel, and has dug 411,000 cu. yd. of gravel from a depth of 54 ft. in one month.

Of over 5,000,000 tons of ore treated in the State, under 250,000 tons is treated direct for gold and silver. In Blaine County, the Little Rockies region produces about half of this quantity, the principal properties being the Ruby Gulch, August, and Beaver Creek. In Fergus County interest centers mostly around the Barnes-King Development Co. which, after doing much work since 1907, has paid its first dividend of 7½ cts. per share. It operates the North Moccasin, Piegan-Gloster, Shannon, and Kendall mines, the last two recently acquired to end litigation in the one case and add to reserves in the other. Improvements in the mills are to be made, and an aerial tram erected to facilitate ore-transport. During 1915, the plants treated 47,039 and 14,956 tons of $9.80 and $7.34 per ton respectively. A profit of $201,569 was made at the North Moccasin and a loss of $15,993 at the Piegan-Gloster. Prospects for 1916 are good.

The activity of the Helena Mining Bureau early in the year resulted in considerable attention and new capital being devoted to the Rimini, Scratch Gravel, and other districts near Helena, in Lewis and Clark

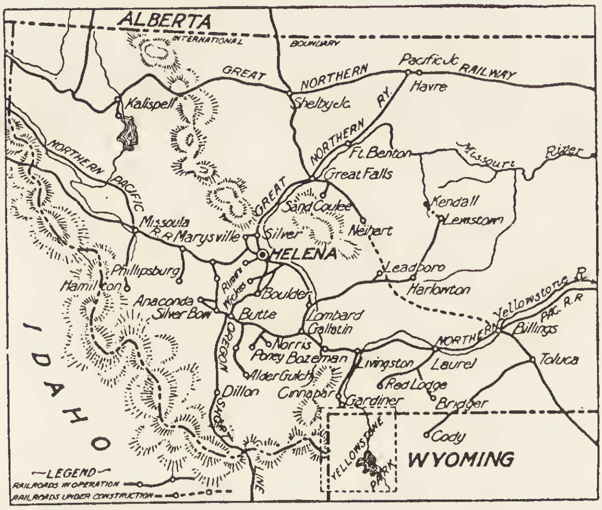


FIG. 4.—Map of Montana. The gold region contiguous to Helena is now receiving considerable attention.

County, and something definite in development and mill construction will result in the current year. Some of the gold deposits are of considerable extent, though low in value. Madison County is the next important gold producer, and steady work was recorded.

Silver is practically a by-product from base-metal ores in Montana. The output last year increased from 12,000,000 to 14,500,000 oz. Copper ores yield 65 per cent., zinc ores 20 per cent., and lead ores 5 per cent. of the silver. The largest increase of zinc ores from Butte added materially to last year's output of silver. The Butte & Superior ore contains 7 oz. silver per ton.

Nevada.—Of the 18 per cent. increase in all metals produced last year, gold accounted for 4 per cent., the yield being nearly $12,000,000. The greater part of the gold came from siliceous ores milled, nearly 40 per cent. from Goldfield, and 20 per cent. from Tonopah. The Goldfield Consolidated treated over 386,000 tons of ore, for $4,100,000, somewhat less than in 1914. Other mines in the Goldfield district helped to make up this deficiency for important tonnages came from the Jumbo Extension, which was shipping about 1500 tons per month in the early part of the year, and subsequently nearly doubled this output. The total output in 1915 was 22,508 tons for $921,780, yielding $403,827 net, of which $333,750 was paid in dividends. The Atlanta and Florence Gold-

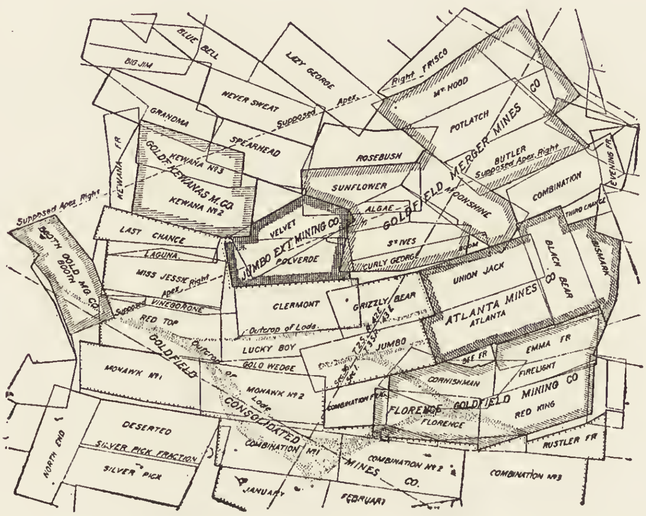


FIG. 5.—Claim map of Goldfield, Nevada, drawn during the apex-suits of 1915.

field also shipped considerable gold ore. Some encouraging results were obtained in the reorganized Kewanas property. Apex litigation early in the year threatened to tie up a large part of the Goldfield district. The Booth Co. sued the Jumbo Extension on the grounds of extra-lateral rights. The former is a considerable distance from the latter, but claimed continuity of the lode from its property to the Jumbo Extension. The matter was amicably settled by the Jumbo Extension Co. giving $15,000 cash and 300,000 shares, in return for that portion of the Booth vein lying within vertical planes drawn through the exterior boundaries of the Jumbo Extension. The vein was thoroughly prospected during the suit, but no commercial ore was found. An apex dispute with the Goldfield

Consolidated, Reorganized Kewanas, and Merger Cos. was also settled, on a share basis.

The discovery of pay ore in the contact zone between the shale and latite opened a new field for exploration in the district, according to J. K. Turner in the *Mining and Scientific Press*, since the conditions revealed at the contact early in 1915 were not known to exist previously. Shale at varying depth overlies the basic alaskite or granite, at 1750 ft. in the southern part of the district. In the Jumbo Extension the rich ore is found on the hanging-wall side of the shale-latite zone. The gold-copper ore of Goldfield is troublesome to treat, and is sent to smelters, but thorough tests with flotation showed it amenable to that process, so a 50-ton plant, the first unit, is ready for work in the Consolidated mill. The Goldfield Consolidated re-treated some of its old tailings. The Nevada Wonder and Nevada Hills properties in Churchill County contributed, though less than in 1914. The output from Round Mountain in Nye County was also somewhat less. This property has a promising future, both in lode and placer mining. A large tonnage of ore has been opened to 900 ft. depth. In the financial year of Mar. 31, 1915, the mill treated 48,230 tons of $6.57 ore, with $44,931 profit. An 8-mile pipe-line was laid to supply water for the gravel deposit, which contains 1,500,000 cu. yd. of $1 per yd. material. Previous lessees recovered $1.55 from 218,818 yd. There was a great increase in the Seven Troughs district, where the Seven Troughs Coalition has added considerably to the gold production. Remarkably rich ore was opened down to 1400 ft., and the mill regularly crushed $100 ore. Yields from a small stamp mill were up to $50,000 per month, and are likely to continue. The National mine in Humboldt County increased its output, but nothing was published concerning the property. The mill was enlarged somewhat, and concentrate shipped. The U. S. Geological Survey published an interesting bulletin on the district, as it did also on the northwest part of the State. There was much activity at the new camp of Willard, 9 miles northeast of Lovelock. Various lessees were shipping gold ore. Though the plant of the Aurora mine was closed part of the year for alterations to the mill, the bullion shipments were far in advance of those in 1914. The Pittsburg Silver Peak Co. dismantled its mill at Blair. The mines at Rochester produced shipping ore and bullion that contained some gold, though principally silver. The output of gold from Tonopah decreased from 128,137 oz. in 1914 to about 113,000 oz. in 1915, giving a production of over $2,335,000 in gold, though the district is primarily a silver one. In Clark County at the Quartette property, ore was treated at the Cyrus Noble mill as formerly, and a new cyanide plant was reported operating at the Colorado Nevada mine. In Elko County, the Bluster mill at Jarbidge and the Rex mill at Gold Circle were active. In the Manhattan district of Nye County, the Big Pine mine was the principal producer, the mill of which was treating 150 tons per day by amalgamation the latter part of the year. Four other mills were operated to smaller extent in the district, the Whitman and Kane, Manhattan Milling & Ore Co., the Associated, and the War Eagle. The principal properties were consolidated. The future of the district depends on large-scale treatment of low-grade ore. The Rand district of Mineral County was notable for its rich ore, especially in the Golden Pen mine. Nothing is available from the Buckhorn mines of Eureka County. A large mill was operated, but there have been metallurgical and other troubles.

The silver production from Nevada mines decreased from 15,455,491 in 1914 to about 14,478,000 oz. in 1915. The decrease was at Tonopah, where the mines were affected by the low price of silver. A great deal of the silver produced was stored at the mines or in San Francisco, it being common for some companies to have several hundred thousand ounces awaiting higher prices. The Montana mine was closed on account of low prices, but leased part of the workings. Yields from the Jim Butler Tonopah, Tonopah Belmont Development, Tonopah Extension, Tonopah Mining, West End Consolidated and several other companies totaled 536,128 tons of ore worth $11,074,922. Dividends were paid by the first four as follows: $200,000, $750,016, $306,613, and $900,000 respectively. Development generally was very satisfactory, especially down to 1500 ft. in the Extension.

Two apex suits threatened to disturb the usual good work of the district. The most important was the Jim Butler *vs.* West End, the former alleging that a good deal of ore had been extracted by the latter. Proof of apex, the vein being termed an anticline, was the main point at issue, according to a lucidly written discussion of the dispute in the *Engineering and Mining Journal.* There was an unusual array of legal and professional talent, and models. The Court decided in favor of the West End, with certain restrictions.

The geology and ore and deposition at Tonopah were thoroughly discussed by J. E. Spurr in a 57-page paper contributed to *Economic Geology* of December, 1915.

During the year ended Sept. 30, 1915, the Jim Butler Co. produced 13,544 oz. gold and 1,158,335 oz. silver from 48,146 tons of ore. A dividend of $171,802 was paid.

At the Comstock district of Storey County, the production also decreased. A good deal of genuine work was done in this area, mainly at a depth of 2500 ft. by the Mexican, Sierra Nevada, and Union companies, with encouraging results. The Mexican mill is again treating good ore.

The old 2700-ft. level was unwatered. The Pumping Association did its share in keeping water down as usual, besides re-opening old workings. The Crown Point Yellow Jacket and Belchers were consolidated. At no time during the past 20 years have the mines at the north end of the lode been so well equipped or harmoniously managed.

The idleness of the Mason Valley copper smelter to a small extent lessened the silver output.

The mines in the Rochester district were active, but particularly so after the advent of the Nevada Short Line railroad. The 150-ton cyanide custom mill of the Rochester Mines Co. was operated, producing gold and silver bullion, and a small mill was active on the Lincoln Hill property, and the Nevada Packard mill was completed. The Rochester Mines Co. drove a lower 1500-ft. adit, and cut ore late in the year. The district may be considered of splendid promise.

In the old camp of Belmont in Nye County, a 200-ton mill using flotation was being constructed to treat dump ore containing silver.

New Mexico.—There was an increase of $241,000 in gold and 566,000 oz. of silver last year, to $1,460,100 and 2,337,064 oz. respectively. The State is primarily a copper and zinc producer. A new mine tax-law became effective during 1915, making reporting of yields compulsory, so that definite figures are available of company operations. Many old districts were revived. The old Aztec mine at Baldy, Colfax County, is again producing rich ore. A U. S. Geological Survey bulletin describes the ore occurrence. The Elizabethtown district of this county contributed some placer gold.

The Mogollon district of Socorro County, 80 miles from Silver City, is the largest precious-metal producer, although it declined somewhat last year, the yield being $512,000 gold and 1,320,000 oz. silver. The Mogollon Mines Co. reported $508,502 and the Socorro Mining & Milling Co., $619,127, of bullion. Good development was done. For better transport the construction of new roads is to be undertaken.

The Cochiti, Jarilla, Pinos Altos, White Oaks, and other districts helped swell the gold and silver returns. The Sante Fe Gold & Copper Co. of Santa Fe County yielded $340,000, which represented a good deal of gold.

Oregon.—Little news is heard from the mining districts of this western State, but gold increased $278,000 to $1,867,100, during 1915. Silver dropped 22,000 oz. to 125,499 oz. This metal is a by-product, so calls for little comment.

One-third of the producing mines have closed during the past 2 years, mostly placers, but the deep mines continued as before. More capital is required for properties of merit. In Baker County, which contributes

85 per cent. of the gold, the Baker, Columbia, Cornucopia, and Rainbow were the principal lode mines operated. The Powder River Dredge Co. started another boat, which is mainly responsible for the State's yield increasing.

Other placer mines are the Osgood, Waldo district, Josephine County; the Layton, in Applegate district, Jackson County; and the smaller mines around Grants Pass, in Josephine County. The gold yield from dredging operations is greatly in excess of that from all other forms of placer mining combined.

A bulletin entitled "Minerals of Oregon" by G. J. Mitchell describing the minerals found in the State, was issued by the University of Oregon.

South Dakota.—This (the Black Hills region) is almost exclusively a gold-producing State, although its other mineral occurrences are varied but little developed. The gold yield last year rose $70,000 to $7,403,500, and silver 18,000 oz. to 197,569.

The Homestake contributed $6,428,787 to the total from 1,573,822 tons, an average of $4.08482 per ton, and paid $2,210,208 in dividends. Large expenditure is being incurred at the Ellison shaft, which is to be sunk to 2000 ft. The Golden Reward cyanide mill successfully treated its ore. The Mogul mill operated steadily on company and custom ore, with an increase in capacity, as was also the Reliance, Trojan, and Wasp No. 2. The Bismarck mine and mill were idle. The new 50-ton cyanide mill on the Rattlesnake Jack mine was operated during part of the year. Sinking continued at the Oro Hondo property. The Wasp No. 2 paid good dividends, largely from the wolframite recovered from its gold ore.

A small production of placer gold was made in Custer, Lawrence, and Pennington Counties. In Pennington County, experimental milling was continued on the gold-antimony-iron-lead-zinc ore of the Home Lode Co., at Silver City, and development work was done on properties near Hill City. The dredge at Mystic, on Castle Creek, was moved to the John Day district, Ore. A custom plant is badly wanted in the Black Hills, and is being considered.

Texas.—There are immense mineral possibilities in this State, some of which are attracting capital, but the production is small. Silver increased from 574,700 oz. to 724,580 oz. The Presidio mine in the Shafter district, Presidio County, produced most of the silver.

Utah.—The output of all metals increased 50 per cent. in Utah last year. It is essentially a base-metal region. Expansion was reported from all quarters, capital was invested, new mills were erected and others enlarged. The most important area receiving considerable attention was the Alta-Cottonwoods, near Salt Lake City. A year ago 17 mines employed 100 men, now 70 employ 700. The U. S. Geological Survey issued a bulletin on the district. While it is a copper-lead-zinc producer, a fair amount of gold and silver will be recovered also.

The mine output of gold increased over 19 per cent. from $3,337,000 in 1914 to $3,908,000 in 1915. Copper ores yielded the larger part of the gold, but large quantities also came from lead ore and siliceous ore.

The Fortuna district of Beaver County witnessed considerable activity, and is promising. Little has been heard of Goldstrike in Washington County lately. Some small mills worked part of the year.

The mine production of silver increased from 11,722,000 oz. in 1914 to 13,073,471 oz. in 1915. Much of the silver is derived from the lead ore of Bingham, Park City, and Tintic, and smaller quantities from copper and siliceous ores.

Washington.—Gold returns show a decrease of about $126,000 to $461,600, and silver 127,000 oz. to 213,887 oz. last year. The Republic district of Ferry County was responsible a good deal for this, but arrangements made there should help to remedy this during the current year. Other counties yield very little from lode mining. Placer operations increased, especially in Kittitas County. Reports from scattered regions indicate a fair revival, which should be apparent in 1916.

Other States.—While the Eastern or Appalachian States—Alabama, Georgia, Maryland, Pennsylvania, North and South Carolina, Tennessee, Vermont, and Virginia—have produced $50,700,000 since 1799, the annual yield is only a total of around $170,000 gold and 100,000 oz. silver. The latter is a by-product. North Carolina is the largest producer, and will increase. Placers yield a few thousand dollars.

Wyoming produced gold worth $14,000 and 2910 oz. of silver.

Gold and Silver Mining in Foreign Countries

Naturally, under present circumstances one can not expect to be able to find available as much foreign material as is desirable, particularly from some of the more remote regions. The following is given as the best information available in regard to the various important producing fields.

Africa

Rhodesia.[1]—In 1915 the gold production of Rhodesia reached a total of 915,029 oz. valued at £3,823,258, an increase of 60,549 oz. and £243,049 over 1914. During 1915 the work of the mines was hampered by the departure of many experienced men to the war, by the shortage of machinery and battery spares and by the general rise in prices. Despite these

[1] From *So. Afr. Min. Jour.*, Mar. 4, 1916, and *Eng. Min. Jour.*

factors the production was well maintained. In 1910 Rhodesian mining had the benefit of a boom, and many new mines were started up with adequate capital and high hopes of large profits. The Consolidated Gold Fields of South Africa has the controlling interest in most of these properties, but so far the results, as regards profits, have been disappointing. The leading mines of Rhodesia are: The Globe and Phoenix, which, despite patchy development values in the bottom levels, has well maintained its output and the value of its reserves, but its prospects are clouded by litigation. The early administrators of Rhodesia unfortunately adopted the American apex mining law. Fortunately most of the ore deposits of Rhodesia have been of simple structure, and so far no serious litigation has resulted from this law. Now, however, a neighboring company claims the apex rights to one of the richest ore-bodies in the Globe and Phoenix mine and an interesting lawsuit is in prospect, as there is no precedent here as to the definition of the terms in which the law is expressed. Though the law is undoubtedly taken from American practice, it is doubtful if a British judge would be guided by American precedents. In August, 1915, 6245 tons was crushed for a yield of 7569 oz. and a profit of £18,000. Ore reserves are valued at about £1,300,000. The Shamva mine is working a large ore-body by open quarry and tunnels in a large hill. For the quarter ending June, 1915, 148,202 tons was crushed with a value of £116,575 and a profit of £57,166, working costs being about 8s. per ton. The ore reserves have been reduced from 2,400,000 tons to 1,789,500 tons, valued at 5.43 dwt. The ore-body contracts badly in the lower levels, but a crosscut on the fifth level has recently disclosed 40 ft. of ore assaying 6.11 dwt. The plant consists of 56 Nissen stamps and tube mills. Of the older producers the Giant mine is nearly exhausted and milled 5800 tons for a yield of £3591 and a profit of £588 in August. The Eldorado mine suffered from a shortening of the ore-shoot on the fifth level; two reefs were payable over a total length of about 1000 ft. On the sixteenth level the ore-body is 140 ft. long, with a value of 12.9 dwt. over a width of 8 ft. The Gaika mine, near the Globe and Phoenix, milled in August 3264 tons for a yield of £7168 and a profit of £3039. The ore reserve is, however, only about a year ahead of the mill. The famous Lonely mine shows a lower grade and a shortened ore-body in depth. Ore reserves are 135,226 tons, valued at 14.66 dwt. per ton. On the twelfth and thirteenth levels good values have been found. In August 5000 tons were milled for £11,492 and a profit of £3892. The Thistle-Etna, which has been milling about 3000 tons per month, is now nearly worked out; but a new producer in 1914, the Fred mine, has been milling about 2000 tons per month for a yield of £2 to £2 10s.

per ton. The great disappointments as regards profits have been the mines treating refractory ores.

The Cam and Motor started production with 1,000,000 tons of ore valued at 40s. per ton developed, and a large and expensive plant for roasting and treatment on West Australian lines was erected after an experimental plant had been run some time. An extraction of 85 per cent. was anticipated. Extractions were at first only about 60 per cent., and the expenditure was increased for additions to the plant. Extraction is now about 70 per cent. In August 12,849 tons were treated for a yield of £20,565 and a working profit of £4401. On the sixth level the ore-body shows some signs of shortening in length and values appear more irregular. The Giant mines have taken an interest in the Cam ore-body near the Motor ore-body. The Bell Reef Development Co. has a capital of 181,000 shares and owes £54,000, and has erected another expensive roasting plant. The ore takes too long to roast, and an Australian expert is being called in. In 1914, 34,202 tons were treated for a yield of £71,424, showing 82 per cent. recovery, but working costs were £60,096. On the seventh level the ore-body is 660 ft. long, assaying 9.4 dwt. over 47 in. Ore reserves are 53,007 tons. The Antelope, with a less refractory ore, treated 4011 tons for a yield of £8579 and a profit of £1990. Costs are 30s. 9d. per ton. On the twelfth level the ore-body has been developed for 249 ft. assaying 14 dwt. over 61.6 in. Ore reserves are about 50,000 tons. The Golden Kopje has a plant of 60 stamps, three tube mills and Burt filter, and treats 12,000 tons per month. The ore reserves are valued at 7.6 dwt. for 290,200 tons, but owing to hanging wall of slopes being soft and caving, the recovery has so far been only about 25s. per ton with a cost of 23s. The Falcon mines work a large ore-body showing auriferous copper glance in quartz. This is concentrated in a flotation plant, and concentrates are smelted to matte, which is exported. Ore reserves are 874,000 tons, valued at 49s. for gold, silver and copper. For the quarter ending June, 38,889 tons yielded metals of a value of £81,343, working costs £73,642, working profit £7700, capital outlay £15,750. As there is a detention debt of about £200,000, the prospect for shareholders in this and the other companies mentioned is not a brilliant one. In the Enterprise district, the Planet, Arcturus and Slate mines have developed about 300,000 tons of ore valued at about 45s. per ton, of a refractory character similar to the Cam and Motor, but the Goldfields Development Co. has not yet raised capital to instal a plant to treat them. Almost the only other large mine of promise is the Sabiwa in the Gwanda district, which has developed 170,000 tons of 11-dwt. ore. Unfortunately, few discoveries of either large or small mines are being made. When the present ore-bodies are exhausted, the output must decline.

Transvaal.[1]—Last year the Transvaal mines produced 9,033,671 oz. fine gold, valued at £38,627,461 ($187,946,473). This is 715,532 oz., value £3,039,386, better than the total for 1914, and 30,628 oz., value £130,099, less than the record production of 1912. The totals for the past 15 years are as follows:

	Oz.	£.		Oz.	£.
1901	238,994	1,014,687	1909	7,280,545	30,925,788
1902	1,707,661	7,253,665	1910	7,533,843	32,001,735
1903	2,955,749	12,589,248	1911	8,237,723	34,991,620
1904	3,779,621	16,054,809	1912	9,124,299	38,757,560
1905	4,897,221	20,802,074	1913	8,794,824	37,358,040
1906	5,786,617	24,579,987	1914	8,378,139	35,588,075
1907	6,451,384	27,403,738	1915	9,093,671	38,627,461
1908	7,052,617	29,957,610			

The gold produced in December, 1915, totalled 781,111 oz., value £3,317,949, as against 781,013 oz., value £3,317,534, for November, an increase of 98 oz., value £415. The December total is not quite so good as was expected, mainly owing to a substantial falling off in the returns of the East Rand Proprietary Mines (£20,530), Princess Estate (£4059), Village Main Reef (£4303), and Witwatersrand Deep (£4477). The number of stamps in operation on the Transvaal fields during December was 59 less than in October, although there was very little change in the native labor position. The official output figures for December as compared with those for November are as follow:

WITWATERSRAND	Oz.	Value, £.
December	755,101	3,207,464
November	753,605	3,201,121
Increase	1,496	6,352
OUTSIDE DISTRICTS	Oz.	Value, £.
December	26,010	110,485
November	27,408	116,422
Decrease	1,398	5,937
GRAND TOTAL	Oz.	Value, £.
December	781,111	3,317,949
November	781,013	3,317,534
Increase	98	415

The Witwatersrand returns for December show an increase of £6352 over those for the shorter month. The daily average yield in December, taking it as a 31-day month, was £103,466, as against £106,763 in November, a decrease of £3237. It must be remembered, however, that the batteries were idle on Christmas Day. Substantial increases are shown by

[1] *So. Afr. Min. Jour.*, Jan. 15 and Feb. 26, 1916.

the following companies: Aurora West (£3024), Ferreira Deep (£4201), Modder B (£7535), New Modder (£11,222), Roodepoort United Main Reef (£5115), and Village Deep (£3203). In December the group profits totalled £896,237, showing an increase of £10,845, compared with the total for November. The outside mines show a total decrease of £5937. Of the principal producers the Transvaal Gold Mining Estates and the Sub-Nigel show an increase of £1241 and £1130 respectively, while the Nigel returns a decrease of £1346 and the Sheba total is £2586 below that for November.

In December 10,025 stamps were dropping on the Transvaal goldfields as against 10,084 in November, a decrease of 59. The official figures are as follow:

	Rand.	Outside.	Total.
December	9,495	530	10,025
November	9,530	554	10,084
Decrease	35	24	59

At the end of December the number of natives employed by the W.N.L.A. and contractors was as follow:

Gold mines	209,438
Coal mines	9,309
Diamond mines	132
Total	218,879

For the 3 months the figures are:

	Oct.	Nov.	Dec.
Gold mines	210,017	210,068	209,438
Coal mines	9,513	9,432	9,309
Diamond mines	....	....	132
	219,530	219,500	218,879

The most important item with regard to labor was the abolition of the flat-contract system by companies affiliated to the Transvaal Chamber of Mines. This took place as from June 1, existing contracts remaining in force until their expiration. Under this system a miner was paid a fixed sum per square fathom broken, irrespective of subsequent variation in the nature of ground during the period of his contract, and out of this sum he had to provide explosives and native labor. His remuneration, therefore, was liable to great variation as his work progressed, and to the system was attributed the migratory character of underground labor. No particular method of payment was substituted in place of this system, it being left to those concerned to arrange matters so that, in accordance with the wishes of the Government, all mine employees should obtain a certain definite daily wage. The abolition of the flat-contract system was among the recommendations made by the Economic Commission and the Dominions Royal Commission. A joint committee of the Transvaal Chamber of Mines and of mine employees was formed to consider the cost of living and a demand of mine workers for an increase of wages. A memorandum of agreement was adopted on July 23 and accepted by the mining groups and the workers' unions. The terms of the agreement related chiefly to wages, hours and overtime.

The dividends declared by the gold mines of the Rand during the year 1915 totalled £7,516,313, as compared with £8,070,700 during 1914, thus showing a decrease of £554,346. It must be remembered, however, that during 1914, the total was augmented to the extent of £520,000 by the distribution of accumulated profits by the Robinson and Ferreira companies. The Crown Mines dividends were at the rate of 65 per cent. as compared with 85 per cent. for 1914, and 110 per cent. for 1913, this result providing one of the disappointments of Rand mining of recent years. Of all the big producers, Randfontein Central gives the poorest results, or nothing was paid in 1914, and though 2½ per cent. was paid in 1915, the additional capital raised by the issue of shares absorbed more than this dividend. As stated elsewhere, the Far East Rand provides all the hope for the future nowadays, and of the individual new mines in that region, Geduld, Springs, and Modder Deep are at present the most in favor, though Van Ryn Deep and Government Areas are also going strong.

The results at the Randfontein Central during 1915 has proved as disappointing as ever. The income from the yield of gold was £2,858,786, the working cost was £2,204,588, expenditure on shaft-sinking, etc., £217,000, development £103,000, debenture interest £171,648, provision for redemption of debentures £86,400, contribution to Miners' Phthisis Fund £48,600, profits tax £66,000, other rates and charges £55,900, total £2,958,136. During the year £150,000 additional capital was issued, and £108,592 was paid as dividend, being at the rate of 2½ per cent. The balance carried forward is £48,420, as compared with £101,362 brought in from 1914. The directors inveigh in no measured terms against the Government assessment for profits and contribution to the Phthisis Fund, though to the outsider these items appear small for so extensive a property. A new method of working the mines during the present year is promised, presumably to consist of reducing the tonnage and selecting the ore.

The two collapses in No. 2 shaft at Ferreira Deep, in December, 1914 and April, 1915 respectively, had an adverse effect on the profits during the financial year ended September 30. The amount of ore milled during the year was 42,730 tons less, at 625,800, and the working cost £614,852 or 19s. 8d. per ton as compared with £585,930 or 17s. 6d. per ton. The fall in the grade of the ore mined also decreased the profits, for the output was £1,070,785 or 34s. 3d. per ton as compared with £1,236,631 or 37s. per ton. The working profit was £445,933 as compared with £650,701. The richer ore in the west part of the property is gradually being exhausted and a continually increasing proportion of lower-grade ore from the east section will in future be mined.

West Africa.—Returns of gold yields for the past 2 years are as follows:

1914. Oz.	1914. Estimated Value.	1915. Oz.	1915. Estimated Value.
30,995	£128,862	34,972	£143,649
29,929	123,169	34,622	144,034
31,795	131,392	37,307	153,770
32,063	131,697	36,319	149,978
35,219	145,227	34,402	142,123
35,851	147,289	32,773	135,289
37,156	152,923	34,001	140,290
36,611	150,386	33,455	139,364
37,525	154,316	32,810	135,744
38,879	159,410	34,300	141,771
37,610	154,674	29,496	122,138
35,877	147,699	37,816	158,323
419,510	1,727,044	412,273	1,706,473

The following figures on the work of December, 1915, show the relative importance of some of the principal companies.

Mine.	Tons.	Value.
Abbontiakoon	11,707	$130,000
Abosso	9,732	72,000
Ashanti	10,778	195,000
Cinnamon Bippo	4,167	34,000
Prestea Block A	23,500	178,000
Taquah	5,720	82,000

Asia

China (By T. T. Read).—The gold exports of China in bars and dust, during 1914 were valued at $8,950,000. No statistics are available as to the point of origin, though most of it comes from the three Manchurian provinces, and the adjacent parts of Mongolia. A Gold Mining Bureau has been organized to have charge of the industry in Hei-lung-chiang, the most productive province of Manchuria. There are five official mines in this province, one semi-official one, and doubtless many unofficial enterprises, since the official in charge of the Bureau reports that the annual output of the province in recent years has averaged 100,000 oz., of which only a small part passes through official hands, the miners selling their output to Russian buyers. Steps are now being taken to keep this gold in China, where the building up of a gold reserve is the first essential step toward putting the currency on a gold basis. No recent reports have appeared concerning the large Russian gold mining company in Mongolia. Quite a little gold is produced in SSu-chuan, where the largest enterprise is at Moho, 50 miles northwest of Ning yuan-fu, where some 1200 men are employed. Funds for developing the mine were provided about a year ago by the Government and American mining equipment has been purchased but the unsettled political conditions in this province during the year have probably hampered the work.

Total imports of silver into China in 1914 were valued at 16,500,000 Haikwan taels and exports were 30,000,000 taels. About one-half of the imports were bar silver, while five-sixths of the exports were silver coins. No statistics are available as to the native production of silver which is probably fairly large. Most of it comes from Southwestern China, where silver-lead ores are smelted and the resulting bullion cupelled, the litharge thus produced being converted into the red oxide and sold for pigment.

India (By E. S. Moore).—The great gold producer of India is the Kolar field in the State of Mysore. The quartz lode occurs in a band of pre-Cambrian schists surrounded by granite-gneiss, similar to the lenses of Huronian rocks in America. A remarkable feature in the mining operations is the difficulty experienced with the so-called "air-blasts." This peculiar phenomenon seems to be due to a potential energy in the country rock and lode which is permitted to exert itself when the shafts and stopes are opened up. It is not due to the superincumbent weight of the overlying rocks in the stopes because large fragments may be blown off the sides of a vertical shaft only a few hundred feet from the surface. The weight of the overlying rock does, of course, aid in producing the action and masses weighing several tons may be hurled across a stope. Small bits of the rock will fly off the face of the stope in the form of powder thus showing the true character of the explosion. On account of the shocks produced often being of considerable force a seismological laboratory has lately been installed in the camp and a careful record of the tremors is kept. There is small difference observed from month to month except that the blasts may be a little more frequent in July and August when the climate changes slightly.

The output of the camp usually runs about 70,000 tons of ore and 49,000 oz. gold per month. The best known mines are the Mysore, Champion Reef, Ooregum, Nundydroog, Balagphat, and North Anantapur and some of these have furnished extraordinary returns. Their prosperity during the past year may be judged by the statement that three of these mines applied for £40,000 each in the war loan and two others £20,000 and £10,000 each.

The large water power plant at Cauvery Falls has been pushed toward completion to furnish power for the Kolar plants.

The official statistics for India in 1914 show a production of 607,388 fine oz. of gold worth $12,554,730 and 236,446 oz. silver and the estimated gold production for 1915 is placed by Hobart at $11,699,385, thus showing a decrease of $855,345 over the previous year.

The report of the Champion Reef for the year ending Sept. 30, 1915, states that the ore crushed was 211,368 tons and the yield in gold was

140,895 oz. worth £545,338. The dividends amounted to £147,333 or a rate of 56.6 per cent. as compared with 53.3 per cent. for the previous year. Since the beginning of operations in 1892 the amount of ore raised has been 3,657,487 tons with 3,006,454 oz. gold worth £11,692,875. The dividends paid during the same period have amounted to £4,304,966. The reserves of ore reported are 495,015 tons, an increase of 17,631 tons. Between the Glen and Garland shafts drifts have been driven 2000 ft. on the shoot from No. 43 to No. 46 level. A lowering of the grade of the ore in the Glen section is noted. Development amounted to 15,111 ft. 6620 people were employed, 131 being Europeans and 102 Eurasians.

At the time of the writer's visit to the Mysore mine in November, 1914, a handsome circular shaft about 3800 ft. deep and 18 ft. in diameter was almost complete. The cost was estimated at £32 per ft. without steel equipment. Engines of 5000 hp. had been installed and it was intended to handle cages carrying 25 men at a time. The management was considering the problem of installing machinery at the bottom of this shaft and of sinking another circular shaft several thousand feet farther down from this point. The depth of the mine is now over 4000 ft.

Development in the Mysore during the past year seems to indicate a new shoot in the 3266-ft. level and in the property just south of this the Mysore Extension Syndicate is reported to have obtained good results in exploration. On the 2385-ft. level the lode is 3 ft. wide and assays 15 to 25 dwt. per ton. In a raise from the 2160-ft. level the ore is 4 ft. wide and runs 32 dwt. per ton.

The Mysore shares dropped about £1 during recent months but in the past it has paid enormous dividends; up to 150 per cent. on some of the original shares which were bought at a low figure.

The North Anantapur Gold Mine decreased its output considerably but the value was much greater and a dividend of 25 per cent. on the preference and 5 per cent. on the ordinary shares was declared. The report for the year ending June 30, 1915, shows that 27,860 tons running 13 dwt. per ton were milled for 14,855 oz. of gold worth £62,945 compared with 25,450 tons running 9.7 dwt. for 11,067 oz. worth £45,888 the previous year.

At the Balaghat mine a new hoisting plant has been installed and conditions appear to be more favorable than in the past. It is stated that on the 2700-ft. level ore as high as 22 dwt. extends over 4 ft. and as high as 15 dwt. over 7 ft. in the south drift and in the north drift 15 in. of 2 oz. ore has been found in crosscuts on the same level.

The sanitary arrangements around the Kolar mines are very satisfactory. Good drinking water is piped to various parts of the mines and for the purposes of stamping out plague and cholera the coolies are furnished with small houses by the companies. These houses only cost about 8 rupees or $2.56 each and in case an epidemic appears they can all be destroyed by fire at a comparatively small loss.

Japan.[1]—The production of gold and silver increased on account of the increased refining of argentiferous and auriferous copper in electrolytic refineries, gold and silver ores being treated together with copper ores and the resulting black copper refined to electrolytic copper, which is especially demanded as war material. The production of silver increased only slightly as compared with gold, owing to the partial closing down of the Tsubaki silver mine because of financial difficulties. This mine once belonged to the largest silver producer in Japan.

PRINCIPAL JAPANESE GOLD AND SILVER PRODUCERS

	Production, 1914, Kilograms.	Estimated Production, 1915, Kilograms.
Hitachi copper smeltery and electric refinery (Kuhara Mining Co.)	2,717 gold 25,084 silver	3,000 gold 37,000 silver
Sado gold mine (Mitsubishi & Co.)	552 gold 4,250 silver	600 gold 4,250 silver
Kosaka copper smeltery and electric refinery (Fujita & Co.)	338 gold 30,000 silver	350 gold 30,000 silver
Yamagano gold mine (Prince Shimazu)	423 gold	450 gold
Matsuoka mine (Fujita & Co.)	100 gold	500 gold

There are about 28 gold mines and 21 silver mines, but most of them have a comparatively small production. The largest ones are shown in the table. The gold production of Chosen is of course not included in the table. Its value is about 10,000,000 yen.

Australia and New Zealand (By E. S. Moore).—The mining operations in Australia and New Zealand, as in almost all other countries have been greatly affected by the war. Although the demand for gold has stimulated mining in all the British dominions it has not been sufficient to prevent a further decline in the production of these two countries. The cause of decrease is due chiefly to the exhaustion of some of the large ore-bodies or the richer portions of these and the lack of discovery of new deposits to replace the old ones. The famous fields of Bendigo, Ballarat, Kalgoorlie and Waihi seem to have passed their zenith, although still producing large quantities of ore.

There have also been some labor troubles in Kalgoorlie, Broken Hill and elsewhere which have tended to retard operations, although these were not of long duration. The closing of most of the mines for a short

[1] H. W. Paul, *Eng. Min. Jour.*, Jan. 15, 1916. The production for the first 6 months of 1915 is given by the *Japan Advertiser* as 3728.4 kg. of gold and 72,826.7 kg. of silver, increases of approximately 20 and 3 per cent. respectively, over the corresponding figures for 1914.

time and a few of them for a prolonged period, combined with the lack of a market for the concentrates, had the effect of decreasing the silver production of the Broken Hill area.

Owing to the lack of any reasonably reliable data concerning the silver production of these countries it is impossible to determine the decrease in this metal, but the figures given for New South Wales alone are 14,504,889 and 13,360,526 fine oz. for the years 1913 and 1914 respectively. The decrease in the gold production for Australia from 1914 to 1915 is placed at 106,831 fine oz.

To cope with the situation at Broken Hill, the Broken Hill Associated Smelters Proprietary Co., Ltd., was formed at a cost of about £500,000 in order to take over, and increase the capacity to 5000 tons of concentrates per week, the smelter of the Broken Hill Proprietary Co. at Port Pirie, which is located on the seacoast about 250 miles from the mines.

The Australian federal government prohibited the exportation of gold and has formed a Metal Exchange with the object of controlling all metal shipments. Only registered members can deal in metals or metallic products. It is not known yet just what effect this may have upon the small producers since the fees for membership are rather high.

PRODUCTION OF GOLD IN AUSTRALIA (*a*)
(In fine ounces)

State.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915. (*f*)
New South Wales	224,792	204,709	188,857	181,121	165,295	149,657	124,507	132,498
Northern Territory	5,633	5,682	5,109	(*e*) 5,000	(*e*) 5,000	(*e*) 4,600	(*e*) 4,500	2,532
Queensland	465,085	455,577	441,400	386,164	347,946	265,735	248,395	249,360
South Australia	2,898	7,111	6,603	3,537	6,592	7,292	6,000	6,258
Tasmania	57,085	44,777	37,048	31,101	37,973	33,440	27,320	18,547
Victoria	671,208	654,222	570,383	504,000	480,131	434,932	409,706	329,068
West Australia (*b*)	1,596,091	1,576,406	1,422,231	1,338,987	1,282,658	1,314,044	1,232,974	1,210,109
Commonwealth	3,022,792	2,948,484	2,671,631	2,449,910	2,325,595	2,209,700	2,053,402	1,948,372
New Zealand (*c*)	471,967	472,465	446,434	427,385	310,796	343,627	(*e*)361,272	(*e*)350,000
Total Australia	3,494,759	3,420,949	3,118,065	2,877,295	2,636,391	2,553,327	2,414,674	2,298,372

(*a*) From official publications. (*b*) Production reported by the Mines Department; in previous volumes the statistics have represented exports. (*c*) Exports. (*e*) Estimated. (*f*) From *Mining and Scientific Press* given as official figures of mining departments.

New South Wales.—The official report for the gold production of the State in 1914 was 124,507 oz. fine valued at $2,570,322.78, and for 1915, 132,498 oz. fine showing an increase of 7991 oz.

The chief producer is the Cobar district which in 1914 furnished 48,965 oz. fine valued at $1,001,432. The Mount Boppy is the principal mine in this district. The Great Cobar has been re-opened by assistance from the State government. The other districts are Adelong, Araluen, Wyalong, Hillgrove, Peak Hill, and Gundagai. The yield from the dredges in 1914 was 22,974 oz. fine.

The silver production for this State is not yet known for the year

1915 but the official returns for 1914 place it at 13,360,526 fine oz., showing a decrease of 1,144,363 oz. in that year over the year 1913. It is probable that 1915 will show even a further decrease owing to poor market conditions for the zinc ores of Broken Hill from which field the bulk of the silver is obtained. There were also labor troubles at this camp during the year but according to reports received they were settled after a short time.

The report of the Broken Hill Proprietary[1] states: The smelter at Port Pirie was transferred to the Broken Hill Associated Smelters Proprietary Co., Ltd. There were smelted 115,374 tons of which 18,317 tons were oxidized ore and 95,160 tons concentrates and slime and 1627 tons residues from zinc retorts. The silver-lead bullion produced was 59,742 tons. During previous corresponding half year 48,404 tons of bullion was produced. At the mine 15,781 tons of lead concentrate assaying 60.5 per cent. lead and 28 oz. silver per ton was produced.

According to the same journal the report of the North Broken Hill mine ending June 30, 1915 is as follows. Time worked 78 per cent. of normal and amount of ore treated at lead concentrating plant was 123,455 tons averaging 15.8 per cent. lead, 12.9 per cent. zinc and 7.4 oz. silver. During the corresponding period of 1914 it was 156,020 tons of ore. The ore on the lowest level, 1400 ft., is of excellent grade averaging 16 per cent. lead.

The Broken Hill South silver mine has the same participation in the new smelting company as the North mine and the ore raised for the same period was 131,059 tons averaging 14.9 per cent. lead, 14.7 per cent. zinc, and 7.5 oz. silver. For the corresponding period of 1914 the ore raised was 172,421 tons. Dividend paid was $145,800 and the cost of the ore per ton about $4.86. The development is satisfactory and the mine 1470 ft. in depth.

The Sulphide Corporation report for year ending June 30, 1915, shows that 200,079 tons of ore were raised and 197,180 tons averaging 15.5 per cent. lead, 17 per cent. zinc and 12.6 oz. silver were sent to the mill. After the outbreak of the war the mill and mine operated alternate weeks for some time and the time in operation was 9½ months out of 12.

At Broken Hill Block 14, mining of sulphides was suspended at the outbreak of the war but mining of carbonate ore from the upper levels was continued. The report for the half year ending Sept. 30, 1915, shows that 4339 tons of carbonate ore averaging 27 per cent. lead, 14⅙ oz. silver per ton sold for $84,413.34 at a profit of $21,179.88. It will be observed that the oxidized ores at Broken Hill are high in lead and silver but contain almost no zinc.

[1] From *Min. Mag.*, December, 1914 to May 31, 1915.

Broken Hill Block 10 has had a very unfavorable year owing to inability to dispose of concentrates which formerly went to Germany. Report for half year ending Mar. 31, 1915, showed that no ore had been raised and the mill was idle. Development work was continued until Dec. 19 and then the plant was repaired.

Northern Territory.—The gold mining is largely in alluvial deposits and the two main areas are the Darwin mining district in the north and the region of the MacDonnell Ranges in the southern portion of the territory. The production is small and since the inception of mining has had a value of about $10,200,760 to the close of 1915. The production for 1914 was 2532 fine oz. and is estimated at about the same for 1915.

Queensland.—The three main gold fields of this State are Mount Morgan, Charters Towers, and Gympie. The former field first produced extremely rich gold—kaolin and limonitic ore sometimes running 30 to 40 oz. per ton, but has now become chiefly a producer of gold and copper sulphides. The geological conditions here are very complicated and it was only recently that a detailed geological report has been obtained. This was made during the past year by Colin Frazer who recommended the exploration of the Sugarloaf section with the result that an additional ore-body was struck. While this discovery has not fulfilled first expectations it has added somewhat to the reserves.

According to the *Mining Magazine*, the new ore-body is 64 ft. wide and runs 2.33 per cent. copper and 9.66 dwt. gold. A new sintering plant has been added for the treatment of the fine concentrate which had previously been briquetted. The working costs have been reduced 7s. per ton and now stand at 40s. 3d.

The report for the 6 months ending Nov. 30, 1915, shows 62,779 oz. gold compared with 58,196 oz. during the previous half year and 4310 tons copper compared with 4482 tons. About 40 per cent. of ore treated came from outside the estimated reserves. The dividend paid during the 6 months ending May 31, 1915, was £100,000 and the price of copper was £57 compared with £57 during the previous half year.

No official returns are available for the Charters Towers field during 1915. This is a small field and although a great producer since its discovery in 1872 of late years the production has declined. It is estimated that to the end of 1912 the field has produced over £27,000,000 in gold.

In the Gympie field there are some interesting geological features which greatly affect the occurrence of the ore. The gold is almost limited to the localities where the quartz reefs intersect the black graphitic slates. It is also claimed that gold occurs only where the strata have a westerly dip and that enrichment in gold occurs where a normal fault intersects the lode at junction with graphitic slates or "indicators" but not where it is cut by a reversed fault.

South Australia.—This State is a small producer of gold and silver. It is estimated that to the end of 1915 the total production of gold has had a value of £1,001,800. The production for 1914 was 6258 fine oz. of which the Wallaroo and Moonta mines produced 2702 oz. in addition to 2936 oz. silver. The production of the State for 1915 is placed at approximately the same figure as for 1914.

Tasmania.—The Mount Lyell field and the Beaconsfield mining district are the two main gold producers in Tasmania. The former contains a very large lens of low-grade pyritic ore carrying on an average about 0.4 per cent. copper, 1.86 oz. per ton silver and 0.04 oz. gold. The principal mines owned by the Mount Lyell Mining and Railway Co. are the Mount Lyell, North Mount Lyell, Comstock, South Mount Lyell, and Lyell Tharsis.

The report from the Mount Lyell Co. for the half year ending Sept. 30, 1915, showed that the Mount Lyell mine produced 116,296 tons of ore. Of this 109,090 tons contained 0.47 per cent. copper 1.5 oz. silver and 0.8 dwt. gold. The North Mount Lyell mine produced 65,831 tons of ore carrying 6.37 per cent. copper, 1.2 oz. silver and 0.1 dwt. gold. The net profit for the half year was £139,071 as compared with £98,220 for the previous half year. The ore of the Mount Lyell mine is smelted in conjunction with that of the North Mount Lyell in proportion of about 2 tons of the former to 1 of the latter. An account of the pyritic smelting in this field may be found in the *Mining Magazine* for January, 1916, page 51.

In 1913 the ore reserves of the Mount Lyell mine were placed at 2,000,000 tons, the South Mount Lyell at about 300,000 and the North Mount Lyell at 1,000,000 tons.

In the Beaconsfield district the well-known Tasmania gold mine was closed down in 1914 because of water. This had formerly been recognized as a very wet mine and is said to have one of the finest pumping plants in the world. It is down about 1500 ft.

The production for Tasmania in 1914 was 26,243 fine oz. of gold. For 1915 it is estimated at approximately 16,000 fine oz.

Victoria.—Gold was discovered in this State in 1851 and it has been famous for the production of largest of the world's nuggets.

Both auriferous quartz and alluvial mining have been conducted on a large scale, the best known areas being Ballarat, Bendigo, Castlemaine, Stawell, Ararat, Walhalla, and Yarra. The Ballarat deposits are interesting geologically because, like the Gympie lodes, the gold at East Ballarat occurs with "indicators" these being thin beds of slate or sometimes sandstone usually with pyrite and a little quartz. A few of the mines such as the Albion Consols and the Star of the East have paid large dividends but the production of the field is declining.

Bendigo is the most important field at the present day. This field has a length of about 15 miles and a width of 3 miles. It is notable because of its saddle-reefs which are also characteristic of the Stawell and Lauriston deposits. The Victoria Quartz shaft is the deepest shaft in Australia, 4614 ft., and there are 53 shafts in the district over 2000 ft. deep. It is found, however, that mining in the deeper levels is becoming unprofitable. No figures of production are available for 1915 but for 1914 the district produced 163,601 oz. of gold and although this was a reduction over 1913 the number of dividend-paying mines increased from 18 to 23. A further decline in production has occurred in 1915. The Walhalla mine had paid up to 1912 about £2,378,290 in dividends on a production of 1,475,625 oz. of gold.

There is still a great deal of alluvial mining in Victoria. It is strange that in the famous Poseidon lead every nugget found is said by Pittman and Maitland to lie in the vicinity of an "indicator" or thin bed of slate similar to those at Ballarat East and traversing the rock in the floor of the alluvial deposit.

In this region deep alluvial mining is carried on and in some cases freezing of the gravel is necessary. In one shaft observed in the latter part of 1914 they had bored 30 holes 4 in. in diameter to a depth of 203 ft. In these were placed smaller pipes 1¼ in. in diameter, down which brine and ammonia were forced and allowed to freeze on expansion. The cost was estimated at about £12 per ft., but this would probably be less below 80 ft. because a former shaft of this depth has caved in and made excavation troublesome.

According to the *Mining and Scientific Press* the quantity of gravel treated in 1914 by 45 dredges and 40 hydraulicking plants was 13,979,696 yd. against 16,796,585 in 1913. The gold produced was 56,796 oz. against 65,433. The yield per yard was 3.8 cts. in each case.

The total production for Victoria in 1914 was 413,218 and in 1915, 329,068 fine oz., a decrease of 84,150 oz.

Western Australia.—Gold is the most important mineral product of this State and of the total mineral wealth produced to the end of 1912, 54.5 per cent. has come from the East Coolgardie gold field. The chief mining center of this field is the town of Kalgoorlie. Like the Broken Hill deposits the gold-bearing lodes of Coolgardie are in metamorphosed rocks of pre-Cambrian age.

Outside of the Coolgardie deposits one of the most famous is the Great Fingall, near Day Dawn. This deposit produced up to the end of 1912, 1,080,415 fine oz. of gold and 150,470 oz. silver from 1,642,089 tons of ore. The lowest depth to which it had been mined was 2342 ft. The Great Fingall Consolidated started milling in 1900 and until 1908 large profits were paid. Much difficulty has been experienced in recent years with the hanging wall and attempts to fill the stopes with sand have been made but on account of rains this did not prove satisfactory. In 1914 according to the *Mining Magazine* the ore raised was 44,006 tons as compared with 64,255 for the previous year. The yield in gold was 16,207 oz. and in addition 1295 oz. was recovered by re-treatment of accumulated sand and slag. Gold sold for £73,343 and loss for the year was £25,821. Little development work was done.

COMPARATIVE STATEMENT OF GOLD PRODUCTION OF WESTERN AUSTRALIA FOR THE YEARS 1907 TO 1914

	1908.	1909.	1910.	1911.	1912.	1913.	1914.
Tons treated (2240 lb.) ..	3,081,824	3,105,004	2,884,298	2,735,943	2,688,868	2,787,361	2,702,096
Gold yield (fine oz.)......	1,596,091	1,576,406	1,422,231	1,338,987	1,267,845	1,299,089	1,214,239
Value of yield(£)........	6,779,763	6,696,146	6,041,254	5,687,625	5,385,462	5,518,179	5,157,760
Value of yield per ton (in shillings)...............	43.9	43.1	41.9	41.6	40.1	39.6	38.2
Total number of men employed (exclusive of alluvial diggers and prospectors).................	15,130	16,007	15,471	14,794	13,204	13,020	11,722
Profits distributed(£)....	1,487,303	1,358,088	1,028,393	826,976	814,092	906,797	799,392
Profits per ton treated (in shillings)...............	9.7	8.7	7.1	6.0	6.0	6.5	5.9

Working costs per ton of 2000 lb.: 1908, 19s. 3d.; 1909, 19s. 11.5d.; 1910, 20s. 1d; 1911, 20s.; 1912, 19s. 3d.; 1913, 19s. 6.6d.

It is stated by the *Mining Magazine* that the directors of the Great Boulder Perseverance, Kalgoorlie, are seriously considering stoppage of development work not because of lack of ore but because of its low grade. The rich ore was exhausted in 1904 and since that date the profits have been small. Report for 1914 shows that 245,555 tons of ore were raised and 61,150 oz. gold worth £260,860 obtained. This indicates a value of $5.17 per ton. The net profit of £27,996 was carried forward.

The Edna May was spoken of as the "only bright spot" recently in Australian gold mining. An oxidized ore-body has been developed to a depth of 225 ft. Average content 25 dwt. and as the ore is soft and easily mined large profits are being made.

The South Kalgurli Consolidated is a company formed in 1913 to amalgamate the South Kalgurli and Hainault companies of Kalgoorlie. Report for 1914 shows 116,159 tons of ore raised and treated for gold worth £137,682. The net profit was £9634. Considerable diamond drilling was done during the year ending in June, 1915, with fairly satisfactory results.

The Oroya Links at Kalgoorlie produced in 1914, 145,130 tons with

36,950 oz. of gold worth £156,668 or $5.25 per ton. Accounts show a net profit of £14,416 and this yielded a dividend of 5 per cent. The developments continue to expose ore at the Eclipse mine and on Dec. 31, 1914, the reserves were estimated at 160,111 tons averaging 25s. per ton.

The Great Boulder Proprietary, Kalgoorlie, has paid dividends continuously since 1895 and during the last 15 years the yield has been over £500,000 per year. The report for the year ending with 1914 shows that 190,117 long tons of ore were raised, worth £565,543 and the net profit was £300,632 out of which £262,500 has been distributed as dividend, the rate being 150 per cent. Development continues to disclose additional ore in the upper levels and on Dec. 31 the reserve was estimated at 560,647 long tons averaging 18.85 dwt. per ton as compared with 615,114 tons averaging 14.5 dwt. the year before. A 3-year supply is assured for the mill. Diamond drilling has been done in various directions, at depth and in the undeveloped ground outside the present workings without important results.

At the Associated gold mines of Western Australia almost as many tons were raised as in the previous year but the yield per ton continues to decrease. The report for the year ending March, 1915, shows that 127,057 tons were raised and treated for £135,858 as compared with 127,856 tons for £152,105 the year before, the value per ton dropping 2s. 4d. After allowing for expenses and depreciation a loss of £8659 was recorded. It is said that dividends paid between 1898 and 1909 amounted to 150 per cent. on a capital of £500,000.

The report of the Lake View and Star for the year ending Feb. 28, 1915, shows that 104,834 tons were raised from the Lake View and 113,290 tons from the Hannan's Star, a total of 218,124 tons. The yield of gold was worth £252,796. The working profit was £37,136 out of which £32,000, a rate of 16 per cent. was distributed in dividends. Ore is found in the Lake View at 2100 ft., the lowest level.

It has been proven that the main ore-body of the Kalgurli mine terminates between the 1750 and 1850-ft. levels, and development during the last year has not added to the reserves. The year ending July 31, 1915, furnished 125,990 tons with gold worth £249,878. The past record shows a total yield to date of 1,474,280 tons worth £3,854,569 and dividends amounting to £1,540,500 on £120,000 capital.

The Yuanmi gold mine located in the East Murchison district, has struck ore on the fifth level which is superior to that on the fourth. Ore-shoots aggregating 458 ft. in length and averaging 48s. over 4½ ft. have been reported.

It is reported that gold has been discovered on the surface along the railroad between Coolgardie and Kalgoorlie but no further information concerning the find has been received.

New Zealand.—Since no monthly statement concerning the gold and silver production has been published during the past year no figures are available and no definite conclusions can be drawn regarding the progress of mining for the year. Considerable interest was attached to the report of Mr. Arthur Jarman, geologist to the Waihi Grand Junction mine, who considers that the conclusions of Bell and Frazer regarding the dacite in this mine are not entirely correct. The latter considered that there was a mass of intrusive dacite among the extrusions and that the ore-bodies were closely related to this intrusive body and more or less limited by its extent. Jarman's conclusions are that the whole series is made up of extrusions and that ore might be found beyond the limits fixed by the hypothesis of Bell and Frazer.

Considerable alluvial mining is carried on in the mountains of the South Island, but no figures are available.

The report of the Consolidated Goldfields of New Zealand, a company with mines in the Reefton district, shows that at the Wealth of Nations mine 25,470 tons were treated for £40,420 gold. The working profit was £15,954, of which £12,804 was allowed for development and depreciation, but no dividends were distributed. Ore reserves run about 10.85 dwt. per ton. At the Blackwater mines 50,426 tons yielded £100,132 with a net profit of £19,834 and dividends of £12,499 or 5 per cent. The ore reserves are placed at 104,564 tons averaging 15.5 dwt. per ton.

The Progress mines furnished 33,150 tons which were treated for gold worth £47,766 and accounts showed a loss of £7708. The broken and faulted ground in this region offers difficulties in mining.

The mine at Karangahake controlled by the New Zealand Crown Mines Co. has been closed and the Talisman developments are not very favorable so that when all conditions are considered the gold mining operations in New Zealand have not been very encouraging during the past year.

North America

Canada.—The total production of gold in placer and mill bullion and in smelter products in 1915 is estimated at 916,076 fine oz. valued at $18,936,971, as compared with 773,178 fine oz. valued at $15,983,007 in 1914, an increase of $2,953,964 or 18.5 per cent. Although the production has more than doubled since 1907 it has not yet reached the high mark attained during Klondike's best years. The 1915 output was exceeded during each of the 4 years from 1899 to 1902.

Of the total production in 1915 about $5,550,987 was derived from placer and alluvial mining, $9,195,307 in bullion and refined gold and $4,230,677 contained in matte, blister copper, residues and ores exported.

The production in Nova Scotia was about $137,178, or over twice the output of the previous year. The pyrites ores of Quebec carry small quantities of gold and silver though the producers are not paid therefor. No placer recovery was reported from this province.

Ontario has now become the largest gold-producing province in Canada, the production in 1915 from 15 properties being reported as $8,386,956, or 44 per cent. of the total production in Canada, as against a production in 1914 of $5,545,509 an increase of $2,841,447, or 51 per cent. The Hollinger and Acme mines contributed about one-half of the output in 1915 and the Dome nearly one-fifth of the total.

No production of gold has been reported in either Manitoba or Saskatchewan although some development work has been done. From Alberta record has been obtained of the recovery of about $4000 of alluvial gold.

The production in British Columbia was $5,628,982 including $755,000 estimated by the provincial mineralogist as being the output of placer workings, and $4,873,982 recovered from milling and smelting ores. In 1914 the production was $5,224,393 including $565,000 from placer workings and $4,659,393 from milling and smelting ores.

The Yukon production in 1915, including a small recovery from copper ores, was $4,755,721 a decrease of $369,653 from the 1914 production. The amount of gold on which royalty was paid during the year 1915 according to the records of the Mining Lands and Yukon Branch, Interior Department, was 287,254.15 oz., as against 309,691.17 oz. in 1914, and 352,900.04 oz. in 1913. For purposes of the royalty this gold is valued at $15 per oz. although the actual value is probably nearer $16.50. The receipts at the Dominion of Canada Assay Office, Vancouver, were 87,284.35 oz., valued at $1,421,292.37 or an average of $16.28 per oz.

The exports of gold-bearing dust, nuggets, gold in ore, etc., in 1915 are reported by the Customs Department as $16,528,143.[1]

Silver.—The production of silver was 28,401,735 oz. valued at $14,088,397 as against 28,449,821 oz. in 1914, valued at $15,593,630. Silver is the principal metal that did not show an increased production in 1915. The falling off in quantity was very small, however, amounting to only 48,086 oz. Owing to the lower price of silver the decrease in total value was $1,505,234 or over 9.6 per cent.

Of the total production in 1915, 24,653,057 oz., or about 86.8 per cent. is credited to Ontario.

[1] Preliminary Report, Department of Mines.

The production from the ores of Cobalt and other silver camps was 23,568,147 oz. including 19,893,639 oz. in bullion recovered in smelters and cyanide plants in Canada and 3,674,508 oz. estimated as recovered from ores exported to United States smelters. The quantity credited to gold ores was 84,910 oz. The total production in 1914 was estimated at 25,139,214 compared with which the 1915 recovery shows a decrease of 1,571,067 oz.

Of the silver in bullion 10,623,307 oz. were produced in smelters in southern Ontario, and 9,270,332 oz. in the mills at Cobalt, the total in bullion being over 84 per cent. of the production of the district.

The production in British Columbia, representing refined silver, silver contained in smelter products, and estimated recoveries from ores exported, was in 1915, about 3,628,727 oz. as compared with 3,159,897 oz. in 1914, an increase of 468,830 oz., or over 14 per cent.

In Quebec province there is a small silver-content in the pyrites ores shipped, while in the Yukon 58,382 oz. are estimated as being contained in the placer gold produced and recovered from copper ores.

The exports of silver bullion and silver in ore, etc., as reported by the Customs Department, were: 27,672,481 oz. valued at $13,812,038.

The price of silver in New York varied between a minimum of 46¼ cts. in September and a maximum of 56 cts. in December, averaging for the year 49.684 cts. a decrease of 5.127 cts. from the average price in 1914.[1]

Ontario.[2]—Notwithstanding the fact that gold had been discovered in many and widely separated parts of Ontario, production was insignificant until 1912, when the mines at Porcupine began to yield. In that year the output was a little over $2,000,000. In 1915 it rose to about $8,000,000, which was an increase over 1914 of nearly $2,500,000. Of the total yield, all but $750,000 came from the mines of the Porcupine camp. Chief among these is the Hollinger, whose mill was treating 7034 tons per week in November as against 5706 tons in January, and making a gross profit of $46,192 per week as compared with $37,746. The average value of the ore varies but little from month to month. It began in January at $11.10 per ton and in November was $10.34. The total output for the year was about $3,000,000.

The Hollinger, which is paying 4 per cent. dividend every 4 weeks, or 52 per cent. per annum on its capitalization of $3,000,000, has a claim to be ranked among the great gold mines of the world. Its veins are numerous and persistent in depth, and some of them are large. A number of new and valuable veins have recently been found in underground exploration. A six-compartment central shaft is being steadily

[1] Preliminary Report, Department of Mines.
[2] Thos. W. Gibson, *Eng. Min. Jour.*, Jan. 8, 1916.

pushed down, and it is intended to operate the adjoining Acme claims, controlled by the same interests, in conjunction with the Hollinger. The Acme ore is treated in the Hollinger mill, but the returns are kept separate. The yield from the Acme for the 12 months was over $900,000.

The Dome mine is next in importance at Porcupine. Opened on a mass of quartz that showed remarkable value in spots, the Dome speedily took on the character of a low-grade mine, the average value per ton treated in 1914 being $4.25. Richer ore, resembling that of the original Dome, struck on the fourth and fifth levels, has materially improved the Dome's prospects and raised the average yield to $5.50 per ton. The mill is being enlarged and is expected to be in shape next March to treat about 55,000 tons of ore per month. The production for 1915 was about $1,325,000.

McIntyre-Porcupine has recently taken over the Jupiter claims, and under the new management is doing well. The yield for the year is about $750,000. Other Porcupine mines and their production for 1915 are: Porcupine-Crown, $600,000; Porcupine-Vipond, $265,000; and Dome Lake, $105,000. Schumacher, the latest addition to the list, began production in November.

At Kirkland Lake the Tough-Oakes mill went into operation early in the year and has run steadily ever since. The yield was about $450,000, the ore averaging $19 per ton. The Canadian Exploration Co., at Long Lake, won about $260,000. In Munro Township, quartz of phenomenal value was found in the Dobie-Leyson claim, now known as the Crœsus mine. From 800 lb. of rock $40,000 in gold was recovered by hand, and in a shaft 125 ft. deep, with a little drifting and crosscutting, it is reported that a million dollars' worth of gold has been put into sight.

The year was more than ordinarily prolific in promising discoveries. In Boston Township J. K. Papassimakes is developing a claim which shows in places a free distribution of fine gold in dark greenish quartz, and in Pacaud, the next township to the south, Miller and Connell have acquired the McDonough claim, one of the best-looking finds of the year. This is a quartz vein a foot wide and about 2000 ft. long, showing free gold wherever uncovered. At Kowkash, 300 miles west of Cochrane, on the National Transcontinental Ry., a spectacular find of gold in quartz was made in August by E. King Dodds, but on sinking, the values disappeared. South of Dryden, on the Canadian Pacific, near Lake Wabigoon, a narrow and irregular vein showing abundance of free gold was located by E. G. Rognon. These veins no doubt will all be opened up in the near future. Meantime the year closed with a decidedly optimistic feeling so far as gold mining is concerned.

Taken together, the value of the gold and silver obtained in Ontario in 1915 exceeded that obtained in 1914, but while the production of gold is going up, that of silver is going down. The famous mines of Cobalt have passed their zenith, and their yield is decreasing. The output in 1915 had a value of about $10,750,000—a little over two million dollars less than in 1914. Production was stimulated by the sudden and decided rise in the price of silver in November. Much the larger production of the silver output of Ontario is now refined in the province, partly at the mines themselves and partly by the smelters at Thorold and Deloro.

British Columbia.[1]—As in other years, the production of placer gold was chiefly in the Atlin division of Cassiar district and in Cariboo district. Of an estimated total of 34,500 oz., which was 6250 oz. more than that of 1914 and was also the highest yearly total since 1907, Atlin's proportion of Cassiar's total of 18,500 oz. was 17,000 oz.; Cariboo's yield was 13,750 oz., of which only a small portion came from Quesnel division of that district. Fort Steele division of East Kootenay is credited with 500 oz. and the Omineca division, south of Cassiar, with 400 oz. Yields from all other parts of the province were comparatively small.

Lode gold came from the gold-copper mines of Rossland to an estimated amount of about 156,000 oz. out of a total for the whole province of 257,500 oz. Other contributing districts were Boundary and Similkameen districts, the copper-gold mines of the former (chiefly those of the Granby Consolidated Co. in Phœnix camp, which made an output of about 37,000 oz.) having a total of 44,000 oz. and the Hedley Gold Mining Co.'s Nickel Plate mine in the latter district rather more than 38,000 oz. Mines in the Nelson division of West Kootenay, with the Queen, at Sheep Creek, a long way in the lead, yielded nearly 9000 oz.; the Granby Consolidated Co.'s Hidden Creek mine, near Observatory Inlet, nearly 5000 oz.; the Marble Bay mine, or Texada Island, about 1500 oz., and numerous other mines scattered throughout the active mining districts, the remaining 4000 to 4500 oz. of the total gold production.

Mexico (By E. H. Leslie).—The mineral industry in the Republic of Mexico, during the year 1915, has reached its lowest ebb from the standpoint of production that has been experienced for a great many years. The abnormal conditions, which have prevailed in Mexico since the overthrow of the Madero régime, have been reflected in a steadily decreasing output from the mines, mills and smelters.

In that mining and government, or more properly lack of government, have come to be so closely related in Mexico, I do not think it would be

[1] *Eng. Min. Jour.*, Jan. 29, 1916.

out of place to summarize briefly the political status of our southern neighbor during this period. While our failure to recognize Huerta undoubtedly hastened his fall, it was very evident to those on the ground that he was not the type of man to unite the various contending factions and establish a lasting peace. His numerous *coups d'etat*, such as his summary treatment of the Felix Diaz faction; his arrest and imprisonment of the entire Chamber of Deputies; his uncalled-for antagonism toward his associates in government and his attempts to apply Porfirian principles of government to a people who had outgrown this dictational form of leadership, were all tending to disrupt what little national organization he fell heir to with the assassination of Madero, and as such was a complete impossibility as a force to bring order and stability to the Mexican government.

The retirement of Huerta which was a natural sequence, did not produce a man capable of filling the place made vacant by Porfirio Diaz nor have the developments since that time resulted in anything more than a general state of anarchy. It was hoped that the advent Venustiano Carranza would be a solution of the situation, but it would seem that this is far from the case. Since Carranza first came into power and his subsequent split with the so-called Constitutionalists, there has been an almost continuous shift on the political scenery, one president giving way to another, until at the present time, while Carranza has returned to nominal power as chief executive and has been recognized by the American government, he is generally looked upon as nothing more than a figure head and a further break is almost momentarily expected with his chief lieutenant, Obregon.

This continual state of political upheaval has resulted in a prolonged civil warfare and outlawry which has handicapped all branches of industry and particularly mining. The lack of transportation facilities, the activity of revolutionary bands and outlaws, has kept the country in a continual state of turmoil. Foreign investors and shareholders, who are responsible for over 95 per cent. of the Mexican mining and allied industries, have lost confidence in Mexican ventures with the result that the great part of the mines have been closed down or have been operated only intermittently. In the larger mining centers, such as Pachuca, El Oro, Guanajuato, Zacatecas, Parral, Chihuahua, and parts of Sonora, the work of mining has been fairly continuous but subject to innumerable interruptions in almost every instance.

Smelting operations have been conducted irregularly and at greatly reduced capacities in various localities. The lack of transportation facilities, ore supplies, and unsettled state of the country making it impossible to operate continuously. Among the plants that have made a limited production during this period are the smelters at Chihuahua, Torreon, Aguascalientes, Valardeña, Monterrey, and Cananea.

In addition to the difficulties mentioned in the conduct of mining operations, the subject of increased taxation has not favored production in some localities. Taxes have been added to and multiplied so that they have been an impediment to the industry in many instances. One of the phases of the new law is the imposition of a graduated tax increasing with the number of pertenencias held, the idea evidently being to make very large holdings less profitable following the principle laid down by the Maderistas to place the greatest tax burden on the larger operators. To offset the increased taxation, however, exceedingly low rate of exchange has been a boon to the operator in Mexico during these troubled times. While the value of the Mexican peso has decreased from the standard "two to one" ratio on the old silver basis to a ratio of about twenty-five to one under present conditions the cost of operation at the mines and metallurgical establishments has not gone up accordingly. As a result, when reduced to a gold basis, the cost of mining has been greatly decreased as compared with formerly.

Owing to the irregularities of mining during the past 2 years it is impossible to present production statistics on the gold and silver output, which are anywhere near authentic. From information available, I would estimate the gold production for the year 1915 at $14,000,000 and the silver production at approximately $39,000,000 as compared with $18,000,000 gold production in 1914 and $45,000,000 silver production in 1914. The great part of the gold and silver output of Mexico has come during the past year from the larger mining centers which have been able to operate fairly continuously in some instances, and spasmodically in others. The great bulk of the production has been obtained from the mines of the States of Hidalgo, Guanajuato, Mexico, Chihuahua, Jalisco, Sonora, Sinaloa, and Zacatecas. It will be understood, however, that mining operations in these States have only been possible in certain areas, and in almost every instance have been subject to the handicaps attendant upon the unsettled conditions.

With the limited space afforded it is possible to present only a very brief summary of mining operations during the past year, but the following data as to the status of the gold and silver mining industry will serve at least as an index to the general trend of mining during this period.

Chihuahua.—The mining industry in Chihuahua has suffered particularly in that this State has been a favorite stamping ground for revolutionary bands and the so-called Constitutionalist activity. It was my privilege to visit this part of Mexico during the period when it was under control of Francisco Villa. At that time mines in the Santa Eulalia district were being operated in an almost normal manner. The Potosi, the San Toy, the Buena Tierra, the Velardeña, the Mina Vieja, and other smaller properties were producing and making shipments to the smelter at Morse. Late in the year operations were suspended.

The Cusi-Mining Co. at Cusihuiriachic was also in operation until October, and the Corrigan-McKinney properties operated in a limited manner. Mining operations in the Parral district were also conducted intermittently. The mill of the Alvarado Mining and Milling Co. was in almost continuous operation treating about 300 tons a day, the ore being obtained from the neighboring properties. The Tecolotes property at Santa Barbara was able to operate until late in the year when the Americans were ordered to leave. The Montezuma property in the same district also operated in a limited manner. The properties of the Mines Co. of America have been operated intermittently during the past 2 years, but completely suspended in September, 1915.

As the properties of the company which include the El Rayo mines and the Dolores mines in the State of Chihuahua and the Creston Colorado and La Dura mines in the State of Sonora have in no way suffered any destruction of the company's property it is stated that it would require less than a week to resume operations when confidence is restored. The production of these mines ordinarily totals over $3,000,000 a year. A great many small properties belonging to *scientifico* owners have been confiscated and are being operated by those in favor with the existing powers. While many properties of foreign ownership which might operate are idle and only a restoration of confidence will restore them to their former state of production.

Coahuila.—The mining industry in Coahuila has been pretty much at a standstill. The coal-mining properties have been practically destroyed by revolutionary bands, and the metal mines have operated on an exceedingly limited scale. The Terreon smelter operated part of the year. Some ore was shipped by the Peñoles mines and also by properties in the Sierra Mojada district. Small shipments were also made from the Reforma property near Cuatro Cienegas.

Durango.—The Peñoles mines at Ojuela were in operation until October and some smelting was done up to that time at the company's smelter. Some work was done in the Guanacevi district, but had to be suspended owing to revolutionary activities. This district is one of considerable promise and when mining operators are able to be resumed on a normal scale will undoubtedly be a district of importance. Some work was done by the Bacis Gold Mining Co. but on a very limited scale, the property having been subject to numerous raids making mining and milling operations too hazardous. The Asarco plant was operated during part of the year and also the Velardeña mines. Of the American Smelters Securities Co., several companies in the San Dinas district have been in continuous operation. There may be mentioned in this district the San Vicente, Candelaria, San Luis, and Estasa mining properties. Durango like Chihuahua has been a Villista storm center and the mineral industry has suffered correspondingly.

Guanajuato.—Most of the properties in this district were in fairly continuous operation until late in the fall. Considerable difficulty was experienced due to lack of transportation facilities and a shortage of supplies but by the use of herioc methods a fair showing was made. Among the properties which carried on mining operations may be mentioned the Guanajuato Reduction and Mines Co.; the Guanajuato Consolidated Mining Co.; the Guanajuato Development Co., and others. Bullion shipments were made to the American border on burrows in some instances and a most excellent spirit was shown by the operators.

Guerrero.—The mining in this State has been practically at a standstill. Zapato and his following of outlaws by continuous devastation and lawlessness has made the conduct of mining operations almost impossible. The Taxco district has been practically idle. Negotiations as to the transfer of the Reforma property at Campo Morado have been suspended due to revolutionary troubles and unsettled conditions. This property has been the subject of considerable discussion of recent years and when in a position to operate again will undoubtedly be a larger producer than formerly.

Hidalgo.—The mines of the Pachuca district have been in fairly continuous operation although political disturbances and shortage of supplies have been considerable of an incumberance. Among the larger producers may be mentioned the Santa Gertrudis Mining Co.; Real del Monte Mining Co.; La Blanca Mining and Milling Co.; San Refial Mining Co.; San Francisco Mining Co., and the Blaisdale Coscotitlan properties, which are treating the tailing of the old patio process of years gone by. Latest reports from the district show an abundance of supplies but a shortage of labor.

Jalisco.—The mines of the Hostotipaquillo district have been subject to innumerable interruptions but have been able to operate possibly 50 per cent. of the time. The Cinco Minas has operated fairly regularly although lack of supplies hindered operations at times. When operations were resumed in November, a 6 months' supply of materials was at the property and the outlook was good for steady production. The mill is treating 340 tons a day and the bullion and concentrate is shipped *via* Manzanillo to San Francisco. The El Favor property of the Makeever Bros. of New York was operated intermittently and the same is true of the Mololoa, Bolaño, and Amparo mines. A good wagon road has been built from the Hosto district to the coast which has facilitated the movement of supplies and products.

Mexico.—The El Oro district has been subject to bandit raids which have crippled the industry and greatly curtailed the production. The important mines of the district which have suffered from the disturbed conditions are the El Oro Mining and Railway Co.'s properties, Esperanza Mining Co.; Mexican mines of El Oro, and the Dos Estrellas mines which are just over the State line in Michoacan at Talalpuyahua. When local conditions are taken into account, considerable development work has been done but there is a decided lack of incentive to produce bullion.

Oaxaca.—While the State of Oaxaca seceded from the federal government due to lack of sympathy with the ever-changing political structure, the attempt to conduct the affairs of the State of Oaxaca independently, pending a return to peace has not been altogether successful. Mining has been far from normal. The principal mining districts are Taviche, Ejutla, Ocotlan, and Oaxaca. Great tonnages of ore are said to be ready for shipment when conditions permit, in the meantime, mining operations have been almost suspended.

Sinaloa.—Mining operations have been conducted in some localities where the Arrieta brothers have afforded protection. This State has been largely a Carranza stronghold and Villa with his followers have remained mostly on the other side of the Sierra Madre. The Tajo mine at Rosario is being operated. The Potrero and Palmito companies in the Mocorito district have been in fairly continuous operation. Quite a number of anti-Carranza operators have had their properties confiscated and looted, but Americans and their property in the State have been generally unmolested.

Sonora.—The mines of this State have suffered seriously from revolutionary activities and while mining operations have been conducted intermittently in some localities the situation has been generally discouraging, especially in the central and southern portions of the State. The Cananea and Moctezuma mines have been operated with a fair degree of success, but under the most trying conditions. The Nacozari Consolidated Mines near Pilares made shipments to El Paso. The La Dura property of the Mines Co. of America has been closed. The mines in the Arizpe district have for the most part suspended. The Tigre property operated continuously in the early part of the year, but difficulties subsequently encountered caused the withdrawal of the American employees and the property was sacked by the Rodriguez forces.

Mexico of the present sustains the traditions and history of her past four centuries of history with the exception of the quarter century of peace maintained by the iron will of Porfirio Diaz. Before Diaz, during the first 59 years of the country's independence there were 52 presidents and rulers in Mexico. With the abdication and flight of Porfirio Diaz 5 years ago, Mexico returned to her present path of near-anarchy with the accompanying hereditaments of murder and pillage, of destruction and turmoil, of revolution and outlawry, and of depression and stagnation. In rapid succession, De La Barra, Madero, Huerta, Carvajal, Carranza, Gutierrez, Garza, Chazaro, and Carranza again have taken up the reins of authority only to be promptly forced from office. How long this will continue is the question upon which rests the solution of Mexico's problems. At the present Obregon appears on the political horizon as a possibility but things in Mexico do not happen according to rule and unless the United States brings an end to the present chaos, any prediction as to what the future holds in store can best be summed up in the trite Mexican expression of *quien sabe.*

Central America

Costa Rica.[1]—The principal operations in Costa Rica were those of Abangarez Goldfields, Aguacate Mines, and La Union mine of the Costa Rica Union Mining Co. at Miramar. Abangarez, upon resumption, was operated on royalty by John N. Popham, full operation not being reached until late in 1915. Aguacate Mines worked throughout the year and continued driving its tenth-level adit. Montezuma Mines of Costa Rica is understood to have worked steadily.

Honduras.[1]—The New York & Honduras Rosario Mining Co. operated its mill and mine at slightly increased capacity, milling 118,000 tons for a yield of 1,800,000 oz. of silver and 15,300 oz. of gold. The company did considerable prospecting in the surrounding region, but did not begin production at any new properties. On Nov. 17, 1915, the 35th anniversary of the company's corporate existence and uninterrupted operation was celebrated. The Socorro Gold and Silver Mine, Ltd., is understood to have operated its property at Valle de Angeles. No new operations of importance were undertaken.

Nicaragua.[1]—The Eden Mining Co., a subsidiary of the Tonopah Mining Co. of Philadelphia, continued its campaign of construction. The Leonesa mine at Matagalpa and the Babilonia at La Libertad both assumed a better position in 1915, making profits and repaying some of the advances made by the Lake View & Oroya Exploration, Ltd., of London, which controls these mines. Cristino Hansen operated a 3½-ft. Huntington mill on ore from the Guapinol and Orosi group of mines.

[1] *Eng. Min. Jour.*, Jan. 8 ,1916.

It is understood that the La Luz & Los Angeles Mining Co. continued its operations in the Prinzapolka district. At Wawa, W. B. Milliken was erecting a cyanide mill for the Linda Ventura mine. Options were taken on several Nicaraguan mines by Tonopah and Canadian interests, but were not exercised, owing, it is understood, to insufficient development. In Panama, the old Darien Gold Mining Co. was reported sold to Thomas Arias and associates, who intended to exploit the mine. Some manganese explorations were in progress on the Atlantic coast.

Salvador.[1]—The Butters Salvador Mines, Ltd., operated continuously in 1915, crushing about 40,000 tons for a yield of about $600,000. The Butters Divisadero Co.'s operations were interrupted in the summer by a fire which destroyed some surface buildings and burned the timber of the shaft. To extinguish the fire the mine was flooded, resulting in several months' interruption of crushing. An 11,800-ft. aërial tramway was completed to a neighboring *antigua*, the ore of which has been purchased. Two Bolinder crude-oil engines were shipped from Sweden to supplant the steam engines now used at the Divisadero. The Comacaran Gold Mining Co., at Mineral Hormiguero, increased its milling equipment, treating at the end of 1915 about 6000 tons monthly of $8 to $12 ore. The company operates the Gallardo, Hormiguero and Guadalupe mines.

South America

Bolivia (By Benjamin L. Miller and Joseph T. Singewald, Jr.).—Although during the days of the Incas and also after the Conquest by the Spanish Bolivia produced considerable gold, at present gold mining is of subordinate importance. Placer gold is wide-spread along the eastern slopes of the Andes but the inaccessibility has interfered with the investigation and development of the region. During 1915 the Olla del Oro mine situated near the base of the old volcano of Mt. Illimani was the most active gold mine in the country. It promises to become a large and profitable producer.

The Incaora mine near Mt. Illampu (Sorata) was only worked to a small extent during 1915 because of lack of equipment which was ordered from the United States. The company hopes to materially increase its output in 1916.

During the past decade silver mining, which long held the preëminent position in Bolivia, has become subordinate to tin mining and during 1915 the bulk of the silver came from mines in which tin ores were the chief values. The old silver mines of Pulucayo-Huanchaca, Chorolque, Oruro, and Potosi were all active during 1915.

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

Within recent years the Pulucayo-Huanchaca mines have been the most important silver producing mines although they have not yielded as much silver as the mines of Potosi where silver is still obtained although now secondary to tin in importance.

In those places where tin and silver ores both occur the cassiterite was ignored by the early Spanish mine owners and the enriched silver ores alone extracted. At Oruro it is said that some of the silver ores contained as much as 3000 oz. to the ton. The Compania Minera de Oruro is now finding portions of the veins still left in the enriched silver zone that contain as much as 1500 oz. to the ton while much of the old filling, now cemented by limonite, yields good returns. During 1915 this company worked oxidized ores containing 5½ per cent. tin and averaging 8 oz. of silver to the ton while the sulphide ores contained 2 per cent. tin and 30 to 35 oz. of silver to the ton.

The silver mines of Bolivia although handicapped by scarcity of labor and deficiency of water for ore concentration will long continue to hold Bolivia in the foremost position among South American countries in the production of silver.

The Frontino & Bolivia Gold Mining Co., Ltd.,[1] continued its campaign of improvements, erecting a 50-ton counter-current decantation plant and an auxiliary pan-amalgamation mill for handling concentrates. The company placed a new 1050-lb. stamp mill in operation in September, and the old, or upper, mill of thirty 450-lb. stamps will be remodeled gradually. The Salada mine was closed, but the company acquired an interest in the Cogote and Marmajito mines. The Tolima Mining Co., which operates the Frias and neighboring silver mines, produced 464,234 oz. of fine silver in its fiscal year, ended June 30, 1915. However, owing to the commandeering of its smelting works, the company was compelled to cease shipping "export mineral" and confined its work in the latter part of the year to development. El Recreo, in Ibagué district, and other lode mines for the most part operated steadily throughout the year, but many developing enterprises were stopped for lack of capital.

The largest hydraulicking operation was that of McGuire Bros., who continued to operate La Clara on the Porce River, opened the Miraflores mine across the river, and mined part of the old bed of the Porce, which has been diverted. The richest part of the river bed was not reached in 1915. Vallecitos' hydraulic operations at Anorí were limited by dryness of the season, and Viborita at Amalfi did prospecting only.

Brazil (By Benjamin L. Miller and Joseph T. Singewald, Jr.).—Although Brazil is not primarily a mining country, as are several of the

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

other countries of South America, it nevertheless possesses considerable mineral wealth. Of the developed mineral resources gold is of foremost importance and no doubt will retain this position until means are devised for the development of the extensive deposits of iron ore.

Gold has been found in every one of the states of the Republic but it is in Minas Geraes that the greatest amount of mining is carried on. The first gold mining of Brazil was confined to the placers and even after 200 years of more or less continuous gold washing along the streams, the total annual amount recovered from the placers is considerable. Most of this is obtained from the smaller streams where one or two men dig the gravels with shovels and wash them in their *bateas*. Some attempts have been made during the past few years to work the gravels along some of the larger streams by means of dredges but so far with little success. During 1915 two companies, financed by American capital, were engaged in investigations along the Jequitinhonha River with the intention of later constructing dredges if the prospect work yielded favorable results.

The Jacutinga workings, where the gold occurs in fine stringers extending through loose flakes of specular hematite, have all been abandoned. In former times these deposits, worked by hydraulic methods, yielded large quantities of gold.

At present lode mines are the most productive gold mines of Brazil. During 1915 two mines were in operation, the Morro Velho mine of the St. John del Rey Mining Co. located at Villa Nova de Lima and the Passagem mine of the Ouro Preto Gold Mining Co., near Ouro Preto. Both are in the state of Minas Geraes.

The Morro Velho mine has the distinction of being the deepest mine in the world, its present depth being 5826 ft., while plans are being formulated to extend it still further by sinking another 1200-ft. shaft making a total depth of 7026 ft. The tenor of the ore and the width of the ore-body have undergone little change with increased depth and the limits of profitable mining may not be reached for many years. On account of the increasing heat with depth the company plans to install a plant for cooling and drying the air before it is forced into the mine. According to the last report at hand, during the year ending Feb. 28, 1915, there was 199,234 tons of ore mined with an average value of about $11 a ton. On this the profits were $700,287.12. At that time the ore reserves amounted to 699,704 tons.

The Passagem mine continues to develop and during 1915 was engaged in the erection of a new hydro-electric plant to supply the additional power needed. The ore averages about $7 a ton. The total amount mined during 1914 was 80,138 tons and during 1915 it was undoubtedly somewhat greater although the exact figures are not at hand.

British Guiana.[1]—The gold-mining industry, although not in as flourishing a condition last year as in 1913–1914, still produced the fair amount of 64,982 oz.—a decrease of 17,724 oz. This industry was little affected by the European war. There was a temporary stoppage in the shipment of gold from the Colony, but matters soon returned to the normal with an increase in shipping charges and war-rate insurance.

Comparative statements of the gold production of the Colony and of the various districts during the last 2 years are given in the table. Two districts show an increase—Mazaruni of 12,392, oz. and Potaro of 7535 oz.; all the other districts show decreases. The increase in Mazaruni was due to the workings on the Kaburi Creek, where the activity continued throughout the year. The increase in Potaro is largely due to

GOLD OUTPUT OF BRITISH GUIANA—By Districts

Districts.	1913–1914, Oz.	1914–1915, Oz.
Barima	10,311	7,975
Barama	2,513	1,303
Cuyuni	38,967	11,028
Groete	80	44
Waini	....	3
Puruni	688	383
Mazaruni	10,381	22,773
Essequibo	7,322	1,502
Potaro	12,433	19,968
Demerara	7	....
	82,706	64,982

the fact that gold brought from the Konawaruk district is now placed under that head instead of Essequibo as formerly.

The decreases in Barima and Barama are due to the more or less exhausted state of the placers in those localities, with the consequent diminution of working operations. A decrease of 19,456 oz. in the yield from sluicing operations is due almost entirely to the smaller amount of gold produced by the Pigeon Island placers, Cuyuni River, owing to their desertion by the large number of men who had flocked to that locality during the previous year. The claims in the Kaburi district continued to employ a large number of men, and rich finds were made in Ohio Creek. In Tiger Creek, Potaro, systematic washing operations were carried on by F. W. Hutson with about 200 registered laborers. Damming the creek and digging a canal about three-quarters of a mile in length has insured a water supply for a year's work at least.

Hydraulicking at the Tassawini mine, Barama River, was discontinued and no gold was reported as having been produced from this source during the year.

The quartz mill at the Peter's mine, Puruni River, was put in operation for a few days in March, 1915, by the representative of a prospective

[1] Excerpts from annual report of Frank Fowler, commissioner of lands and mines, Georgetown, Demerara, British Guiana, through *Eng. Min. Jour.*, Apr. 22, 1916.

purchasing company and 108½ oz. of gold cleaned up, which, however, was not brought to Georgetown until after the close of the financial year. The Aremu mine, Cuyuni River, and the Barima mine on the Arakaka Creek, on the right bank of the river from which the mine takes its name, remained closed down throughout the year.

Dredging was actively carried on by the Guiana Gold Co. and the Minnehaha Development Co. in No. 2 Mining District with satisfactory returns. There is large scope for gold dredging in British Guiana, as many of the larger creeks that have been already washed with the tom and sluice would pay to re-work with a dredge. An example is the Arakaka Creek, Barima River, which is conveniently situated for the transportation of the necessary dredging machinery.

The Guiana Gold Co. operated with four dredges throughout the year and paid royalty on 8170 oz. of bullion.

DREDGING RESULTS—GUIANA GOLD CO., LTD.

Name of Dredge.	Gold Won.			Material Treated, Cu. Yd.	Average Value, C. per Cu. Yd.	Length of River Worked, Mi.
	Oz.	Dwt.	Gr.			
Lady Mary	1662	2	10	276,314	12.5	½
Lady Maud	1836	10	2	190,292	19.9	¼
Lady Bertha	2991	17	18	133,833	46.2	⅝
Lady Anne	1851	12	11	272,674	14.0	Various places

"Lady Mary" and "Lady Maud" worked mostly in ground composed of fine material, heavy clay overburden treated where banks were worked. "Lady Bertha" worked very rough and rocky ground for the greater part of the year. "Lady Anne" worked through several rocky patches, but most of the ground was similar to that worked by "Mary" and "Maud." Delay caused in removing "tacoubas," found embedded in river and banks, made good working time impossible on any of the dredges.

Gold won by "Mary," "Maud" and "Anne" ranged from medium to fine; the "Bertha's" gold was mostly medium, but in places coarse gold and small nuggets were found.

The Minnehaha Development Co. operated two bucket dredges—one on the Minnehaha Creek and the other recently erected on the Mahdia Creek. The bullion produced by these dredges was 4438 oz., a considerable increase on the last year's production.

Colombia.[1]—Although the lode mines made important improvements in 1915, the predominant feature of Colombian mining continues to be the new dredging operations. The Pato dredge on the upper Nechí, according to cable advices, had averaged over 33 cts. up to December. Estimating December, the yardage handled would approximate 1,450,000 yd. for a return of over $450,000. During the first half of 1915 the dredge returns were over 50 cts. per cu. yd., but the average for the last 6 months was around 20 cts. The dredge worked outside the tested area for part of this period. The Nechí dredge was launched in September, but had to dig in low-grade gravel for about 2 months before getting into the

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

rich ground across the river. An interruption to operations occurred in November, when the bucket line broke. The Pochet dredge on the Nechí was reported purchased by C. J. London and associates.

The Anglo-Colombian Development Co. launched its dredge on July 20, in the Condoto River, in the western part of the country. While no figures have been given out, the company announced that the yield justified the results reported during the period of prospecting. The gravel contains both gold and platinum. A power survey was being made, and additional dredges are under contemplation. Further prospecting was done by the General Development Co. in this field, and British interests were also prospecting placer areas in the West Coast country. Up to 1915 platinum was recovered only by native methods—that is, chiefly with *bateas* and in small open cuts—but with the installation of dredges in this field the platinum output will probably be increased.

Ecuador.—Gold-bearing quartz veins exist in the mountains in many parts of Ecuador, but the only ones now being developed are those in the district of Zaruma in the province of El Oro. History tells us that soon after the Conquest the Spaniards discovered the natives working important gold mines, and founded several towns because of the mines. The principal ones were Zaruma, in the south in the province of El Oro; Zarmora, in the southeast in the province of Loja; Sevilla del Oro and Logroña del Oro, both in the central part of the Republic.

The only active producing mine is that of the South American Development Co. in Zaruma. Its production amounts to about $300,000, but there is also some production from small placer work among the Indians which will increase this figure somewhat.

Peru (By Joseph T. Singewald, Jr., and Benjamin LeRoy Miller).—Though Peru owes its discovery in 1527 by Francisco Pizarro to the reports of its great wealth in gold that reached the Spanish colonists at Panama, and though the pile of gold collected by Atahualpa for his ransom alone had a value of over $15,000,000, it has never been possible to develop a great gold-mining industry in that country. The annual production amounts to nearly one million dollars; but, if one analyzes the figures, it is evident that the gold-mining industry as such is of little importance. Less than two-fifths of this production comes from precious metal deposits, gold lodes and placers; the rest is obtained from auriferous ores of other metals, and, as in the case of most of Peru's silver output, chiefly from the copper ores. For this reason the department of Junín takes first rank as a gold producer with over three-fifths of the Peruvian output, and over one-half of the entire production comes from the Cerro de Pasco district. Gold deposits are, however, coextensive with the Andean region of Peru and practically every one of the departments in this region, from Cajamarca to Arequipa and Puno, maintains a small production from gold ores and placers.

Numerous attempts have been made from time to time to revive the gold-mining industry on a large scale, but they have always ended disastrously. Among the more important gold mines of the country provided with modern gold-milling equipment are the Gigante in the old Pataz district of the department of Libertad; the new Chuquitamba near Cerro de Pasco, Junín; the Cochasayguas of the Cotabambas Auraria in Apurímac; and the Santo Domingo of the Inca Mining Co. an American concern, located on the eastern slopes of the Andes in the department of Puno. The latter is again idle, however. The activities of the Marañon River Placers were put an end to by the United States postal authorities.

The silver production of Peru now has an annual value of about $6,000,000. Silver deposits are likewise coextensive with the Andean region, and all of those departments maintain a greater or less production, but the only ones of importance are Junín, Lima and Ancachs, which account for over nine-tenths of the total, and over four-fifths comes from the first two departments from mines along the Oroya Railroad and branches. The latter represents the silver-content of argentiferous copper ores of the Cerro de Pasco, Morococha, and Casapalca districts. The ores of the Casapalca district are so low in copper and high in silver, that they might properly be classed as silver ores. In addition there are the silver ores of the Colquijirca mine near the Cerro de Pasco smelter in Junín. The Colquijirca ore-body is a replacement of two beds of limestone separated by a thin parting in a thick series of limestones. The replacement has been chiefly by a black cherty-looking silica and pyrite, associated with which is considerable barite and galena, and a minor amount of silver "sulphurets." A noteworthy feature of this mine are the magnificant specimens of native wire silver that it affords. The average grade of the ore is about 70 oz. silver.

The department of Ancachs contributes about one-tenth of Peru's silver production, chiefly from argentiferous lead ores. The department is characterized by a great number of small active mines, the ores of which are treated in local reduction works of small capacity.

Venezuela.[1]—The local manager of the gold mine known as "Mina El Amparo" reports that the gross output of gold for the 6 months April to September, 1915, inclusive, was $25,443, of which $17,104 was obtained by quartz crushing and $8339 by cyaniding; 197 tons of quartz crushed yielded 221 oz. and 100 tons of sand treated with cyanide gave 76 oz. of gold.

[1] *Comm. Rept.*, Jan. 14, 1916.

Exports of gold from Venezuela for the first 6 months of 1915 were \$680,588 as against only \$217,332 for the same period of 1914.

Consular Agent Henderson, at Ciudad Bolivar, reports that the increased shipments of gold are due to a new placer discovery and that they would have been even larger had it not been for a serious outbreak of beriberi among the miners.

EUROPE

Russia.[1]—The production of gold in 1914 was estimated to be worth about \$27,000,000. There are no records available for 1915, but it is estimated that there will not be a great difference—probably a slight decline. Many of the one-man operations have been stopped, and while no large producer has had a much reduced output, the total will almost surely be less than for 1914. One of the largest producers, the Lenskoe Co., operating in the Lena River region, will produce about \$10,000,000 worth of gold, or about 30 per cent. more than in 1914. This, however, will probably not compensate for decreased output due to the interruption of small operations. The Lenskoe mines nearly all its gold by drifting under the floors of present valleys at a depth of about 70 to 125 ft. from the surface. Because of bad methods and management, the total costs of mining are about \$10 per cu. yd., with labor at \$1 per day and supplies proportionately cheap. Such cost is, of course, unpardonable. One mile of valley has in the past produced about \$55,000,000 worth of gold, or over \$10,000 per lin. ft., which is a record.

There were no important discoveries of new gold fields in 1914 and 1915, although search has been stimulated by the strong demand for gold and the development of some successful quartz mines in the valley of the Yenisei River. The present gold fields are being exhausted, and it is probable that the next few years will witness a continual decline unless some unforeseen stimulus shall come as a result of the war.

Dredging for gold has had its customary precarious year and has only confirmed the fact that, generally speaking, the Russian Empire is a poor place for gold dredging. Prospecting in the Lena region has given renewed hope that, where such wonderfully rich drifting had been done, there may still be something left to be worked by dredging. Recent results are said to indicate the existence of considerable ground, perhaps 100,000,000 cu. yd. or more, under dredgable conditions.

Modified hydraulicking was tried in 1915. Material was hydraulicked to a chain of buckets which lifted it to such height as to give grade for sluice and dump for tailings. This system, which has never been a success anywhere in the world has, seemingly, failed again.

[1] J. P. Hutchins, *Eng. Min. Jour.*, Jan. 8, 1916.

Straight hydraulicking is done in a few places, but only on a small scale. Auriferous high old channels do not exist, and terrace gravels generally exist where topographic conditions are unfavorable. The Russian Empire, speaking generally, has gentle topographic conditions. Thus the Perm Railway between Cheliabinsk and Perm meanders three times from the east to the west watershed of the Ural Mountains. However, there are bench gravels in considerable volume in the Altai Mountains under ideal physical hydraulicking conditions. It is possible that investigation will show enough gold in them to pay. About 95 per cent. of all the gold produced comes from placers.

The Russian government is attempting to increase the output of gold. Thus it is lending money to the owners of gold mines needing capital for equipment or development. It is probable that this policy will not have a good effect and that many of the loans will never be repaid. The price of gold is now 30 per cent. above normal, which about corresponds to the depreciation of the ruble in English exchange.

The report on gold and platinum dredging in Russia during 1914 has been issued by the Consultative Committee of the Gold and Platinum Producers. It is somewhat briefer than usual, excepting the tabular matter, which gives many details. It is stated that the question-forms issued by the Committee were filled and returned by 13 gold-producing concerns controlling 58 dredges, three more boats than in 1913. There was an improvement in particulars given on 53 boats, five more than in the report of 1913. Four companies failed to make any returns at all, namely, the Moscow Timber Co., the Orsk Gold Co., the Northern Yenissei Gold Co., and the Spassky. As was to be expected, the time worked was short of that in the preceding year, though certainly not so far below as a state of war might have justified. The hours worked were 2951 per dredge; compared with 3302 in 1913, and 3437 in 1912. The quantity of gravel washed shows a reduction that is a fair proportion compared with peace times. What is perhaps more surprising is that the returns in gold and platinum, though of course lower than those in 1913, are relatively higher per dredge and in total. The quantity of gravel washed per dredge was 18,451 cubic sajenes (1 sajene = 7 ft.) in 1914, against 19,502 in 1913 and 16,806 in 1912. The resulting production of gold per dredge was R92,860 (1 ruble = about 50 cts.) in 1914, against R92,360 in 1913, and R84,200 in 1912. The reduction in working hours per dredge made 10.6 per cent., but the average gravel washed and the average precious metal produced made respectively a reduction of 5.39 per cent., and an increase of 0.5 per cent. The total quantity of gold and platinum produced by the dredges in Russia and Siberia in 1914 showed a decline of R149,730 compared with 1913, making a reduction of about 2.5 per cent. The grand total of gold and platinum produced from 58 dredges according to the table made R5,205,290. But dealing only with the 53 dredges, respecting which complete details are available, the quantity was R4,921,580; or an average of R92,860 as is stated above. The results per dredge for previous years have been given for purposes of comparison, but one need only say that in 1910, when the result was R73,000, and again in 1906, when the result per boat was no more than R54,100. This, as can be understood, does not necessarily indicate increased efficiency to the extent of the difference between the figures of 1906 or 1910 and 1913, because the dredges now at work are considerably larger.[1]

Gold and Silver Milling in 1915

By H. W. Fox

New developments in the metallurgy of gold and silver during the past year have been few and unimportant, and, with the exception of flotation, the attention of metallurgists has been directed more to bettering the efficiency of the processes now in use rather than to any new processes or changes in the old. The demand for gold caused by the European war has stimulated the production of this metal and all gold mines have been worked to their upmost capacity. This is especially marked in the African fields where the production shows a notable increase. In silver production the opposite condition has prevailed. The price for silver has been low except during the last few months and this, added to the increased cost of silver cyaniding, due to the rise in price of zinc and cyanide, has tended to discourage any expansion in silver milling. Conditions in the latter part of the year have been more favorable and if the market price of silver holds up to the present level there should be more activity in silver milling in the coming year. The application of flotation to silver ores should also help the production of this metal as many low-grade ores where the silver occurs in the form of sulphide can probably be worked more economically by flotation concentration than by cyanidation.

The universal adoption of continuous counter-current decantation in the cyanide process has fulfilled the promise that this method made of its efficiency during the previous year. All of the new cyanide plants constructed during the year have installed counter-current decantation and many of the older mills have changed their flow-sheet to include this method. It can today be regarded as standard practice and the filter is now of only secondary importance in slime treatment. There is no

[1] *Min. Sci. Press*, Apr. 15, 1916.

doubt that the patent litigation of the filter companies hastened the adoption of counter-current decantation but there is so much merit in the method that even without the uncertainties of the filter situation it would have soon earned its present secure place in slime treatment.

Considerable attention has been given to the question of precipitation and the use of aluminium powder has made some progress although zinc is still the foremost precipitating agent. The high price of zinc has stimulated renewed investigation of electrolytic methods of precipitating and at several plants it is the subject of extended experiments. It is to be hoped that this renewed interest may lead to tangible results.

It is in flotation that the greatest promise of a distinct advance in precious metal metallurgy can be looked for. A large amount of experimental work is under way and some plants have already completed installations of this process on a working scale. How far flotation will encroach upon the field now filled by amalgamation and cyanidation is the subject of some speculation but that it will have a distinct place in gold and silver metallurgy there can be no doubt. Results show that in many cases amalgamable gold has been floated and in ores where the gold is carried in sulphide and telluride minerals a satisfactory extraction is now being made in several plants. On silver ores it would seem that concentration by flotation will have a better chance for competition with the older processes than in straight gold ores, especially as an aid in recovering the silver sulphide in the slime.

The most notable installation of flotation on a straight gold ore is that at the Independence Mill, in the Cripple Creek district, where the engineers of the Portland Gold Mining Co., who have made such a success of cyaniding the low-grade telluride ores of this district at the Victor mill, are completing a 1000-ton installation of this method in connection with the cyanide process. Here the ore is crushed in water and, after classification, the slimes go to flotation cells and the sands, after gravity concentration on tables, are leached with cyanide in tanks. The concentrates from both the flotation cells and the tables are shipped to the company's cyanide plant at Colorado Springs where they are mixed in small amounts with mine ore and, after roasting and re-grinding, are cyanided in the regular course of treatment. Considerable difficulties are met with in the mechanical handling of the fine wet concentrates but as to what chemical troubles result from this method of treatment of the flotation concentrates there are no figures available at this time.

The disposition of flotation concentrates from gold and silver ores is one that may prove a stumbling-block at many plants which are not so fortunately situated as the Independence mill which has its own roasting plant for treating this product. So far experiments in the chemical treatment of the raw concentrates have not proven very encouraging in their results. The reason for this is brought out by Charles Butters,[1] who says:

"The difficulties attending the treatment of concentrate by cyanide are well known. The process of concentration collects in a small bulk not only the valuable constituents of the ore but also those substances that act as cyanicides, or which are readily converted by oxidation or otherwise into cyanicides, so that their influence, per ton of material treated, is greater than would be the case with the unconcentrated ore. Heavy minerals such as the sulphides of iron, copper, lead, arsenic, antimony, zinc, and double sulphides such as mispickel, proustite, pyrargyrite, and bornite, naturally tend to accumulate in the concentrate. If some interval elapses between the formation of this concentrate and its treatment, oxidation may take place, with formation of sulphates, arseniates, and antimoniates, which are still more detrimental to cyanide treatment than the original minerals. These difficulties have been wholly or partly overcome by the adoption of modifications in the treatment, such as preliminary water, acid, or alkali washing, roasting, fine grinding, the use of special solvents, such as bromo-cyanide, and prolonged contact of the material with cyanide, extending in some cases to over a month.

"In the case of concentrate produced by flotation, the minerals composing the product are substantially the same as those obtained by gravity concentration, consisting of the sulphides and double sulphide of the heavy metals, and it is to be expected that the same difficulties will be encountered in their treatment. But as the concentrate also contains a considerable part of the oil, tar, or other flotation agent, the presence of this foreign matter must be taken into account. In some cases, this circumstance introduces an additional difficulty. A part of this organic matter is soluble in the cyanide or alkali used in the process, and the solution so formed may be capable of absorbing oxygen. The effect produced by carbonaceous matter in precipitating gold and silver previously dissolved by cyanide is well known and has been a source of much trouble in many localities. Some of the constituents of this matter are not easily eliminated and appear to resist oxidation even at a high temperature; roasting under ordinary conditions does not completely remove the carbon; it is probable that a portion derived from tar remains in the graphitic form, capable of acting as a precipitant for gold or silver."

This difficulty, however, should not be regarded as insurmountable

[1] *Min. Sci. Press*, **111**, 954.

and will probably be solved by some of the many metallurgists now working on the problem. But its successful solution is vital to the wide adoption of flotation in gold and silver milling and the results of the work now under way will be watched with much interest by many operators who see in flotation an aid in bettering their extraction and working costs.

There was considerable new construction undertaken during the past year and a number of plants commenced operation. The Tom Boy Gold Mining Co., Telluride, Colo., completed its 400-ton cyanide tailings plant. The Belleville Tailings Association began operation in a 130-ton cyanide plant for treating old tailings at Belleville, Nev. The Golden Gate Mining Co., Greenhorn, Ore., installed a 35-ton amalgamation mill. The Elko Prince Leasing Co. at Midas, Nev., started operations in its 60-ton all slime cyanide plant. This mill treats a quartz ore carrying gold with silver sulphide running about $40 per ton. The ore is delivered into bins which discharge upon a short conveyor feeding a Telsmith gyratory crusher from whence the crushed ore is elevated to a fine-ore bin. From this bin a special conveyor carries it to a 4-ft. Marcy steel ball mill which discharges into a 5 by 14-ft. tube mill in closed circuit with a Dorr classifier. The Dorr system of countercurrent decantation is used with three Dorr agitating vats and two Dorr tray thickeners. The pulp then passes to an Oliver filter. Precipitation is by the Merrill zinc-dust system. Power is supplied by a 185-hp. Deisel oil engine.

The Rochester mill at Rochester, Nev., was started on Mar. 30, 1915. It is a typical installation of a continuous decantation cyanide plant, operating on silver ore, using Dorr thickeners exclusively without a filter. The ore from the Rochester mine, or from other shippers, is delivered from railroad cars to five 60-ton bins, trammed to the mill, weighed, and dumped over a grizzly with 1½-in. openings to a 20 by 10-in. Blake crusher. The crushed ore, with the undersize from the grizzly, is elevated to the top of the sampler which is equipped with crusher, rolls and Vezin samplers. After sampling the ore is delivered to two 5-stamp batteries of 1550-lb. stamps and is crushed in solution. From the batteries the ore flows to a Dorr duplex classifier which is in closed circuit with two 5 by 16-ft. tube mills. The discharge goes to the first thickener; the underflow from this thickener goes to the first agitator, the overflow to the precipitation boxes. The pulp from the first agitator goes to the second agitator after being diluted with clear solution from the second thickener, from the second agitator the pulp goes to the second thickener and, after thickening, to the third thickener and thence to the fourth, fifth and sixth thickeners after respective dilutions. The settled pulp from the sixth thickener goes to waste.

The new Packard mill at Rochester, Nev. also started up during the summer. The ore treated is a silicified schist interspersed with quartz stringers. As broken, it is of a soft, friable nature and is easily crushed. The principal value is in silver and of a form readily acted upon by cyanide. The ore is trammed in cars to the crusher plant, weighed on recording scales and a small amount of lime is added before dumping into the crusher bin. It is crushed in a No. 5 McCully gyratory crusher to pass a 1¼-in. ring, elevated to a screen with ⅜-in. square openings, the coarse passing to a 36 by 16-in. Garfield roll. It is then conveyed to the mill ore-bin of 100 tons capacity. From the bin it is fed to a tube mill 6 ft. in diam. by 5 ft. long. At this point solution is added. From the tube mill the pulp is discharged to a Dorr classifier, where the fine slime is removed. The sands go to a 6 by 10-ft. tube mill in which they are ground in closed circuit so that all passes 200-mesh. About 85 per cent. of the values are dissolved in passing through the tube mills. The pulp is elevated to a Dorr thickener at a dilution of five to one. The clear overflow goes to the pregnant solution tank and the thickened pulp to a Dorr agitator where it receives a 24-hr. agitation. From the agitation it passes to three Dorr thickeners arranged for counter-current decantation. From No. 3 thickener the pulp goes to an Oliver filter. Precipitation is by zinc dust in two Merrill presses. Two men on a shift handle the mill which has a capacity of 100 tons per 24 hr.

The remodelled mill of the Amador Consolidated at Amador City, Cal., was started up on May 1, 1915. It involves a departure from the usual mother lode practice as no amalgamating is done in the mortars. The ore from the crusher bin is fed to a revolving screen with ⅜-in. openings; the oversize goes to the stamps, the undersize, with the discharge from the stamps, goes to drag classifiers, the sand discharge of which is fed to two Hardinge mills, the overflow to a thickener. The discharge from the Hardinge mills goes to the Hardinge amalgamators which are attached to and revolve with the mill. The discharge from the amalgamator passes over the usual copper plates and then to a hydraulic classifying launder; the slimes from this go to the thickening tank and the different grades of sand to separate tables; the thickened slimes go to slime tables. The concentrates from all the tables go to a second set of amalgamating plates and are then dewatered and trammed to the cyanide plant where they are ground in a 4½-ft. by 72-in. Hardinge Mill to pass a -200-mesh screen. This Hardinge is in closed circuit with a drag classifier and is equipped with an amalgamator which discharges on to a small copper plate. The overflow from the classifier is pumped to a tank equipped with Trent cyaniding apparatus. Precipitation is done with zinc dust in two 5-ton tanks equipped with mechanical agitators. The precipitates are filtered with canvas bags, each enclosing an inner bag of fine muslin.

The Pittsburg-Dolores Mining Co., at Rockland, Nev., started up their new 80-ton mill in the latter part of the year. In this mill the coarse ore from the mine is delivered to a grizzly and after crushing is fed to a trommel where solution is added. The oversize from the trommel goes to rolls and thence to a bucket elevator. The undersize from the trommel goes direct to the elevator. This arrangement is expected to keep most of the clay away from the rolls. The discharge from the elevator goes to an 8-mesh Bunker Hill screen, the oversize from which goes to the fine rolls and then back into the elevator; the undersize going to a Dorr classifier. The sands are fed to the tube mill and the slimes go to the first of five 5 by 30-ft. Dorr thickeners. The Dorr system of continuous counter-current decantation is used. There are three 22 by 19-ft. Dorr type agitators. At Nelson, Clark County, Nev., the Colorado-Nevada Mining and Milling Co. erected and put in operation a 75-ton plant using the Dorr counter-current decantation followed by an Oliver filter. The Techatticup Syndicate also installed the Dorr counter-current decantation system in their new 40-ton plant at Nelson. The Yuba Leasing and Development Co., at Pioche, Nev., completed a 50-ton concentrating and cyanide plant. At Jerome, Ariz., the Copper Chief Mining Co. completed a 200-ton cyanide plant. This plant uses counter-current decantation followed by an Oliver filter.

The Melones Mining Co., Melones, Calaveras County, Cal., started up their slime plant for the re-treatment of tailings using Dorr counter-current decantation. This undertaking is noteworthy from the low grade of the product treated, the slimes running only 80 cts. per ton. At Masonic, Mono County, Cal., the Stall Brothers installed a 60-ton, 10-stamp mill with tube-mill and cyanide equipment. The Brunswick Consolidated Gold Mining Co., Grass Valley, Cal., built a 40-stamp mill with a capacity of 120 tons per day. The Empire Co., at Grass Valley, have completed a 60-stamp mill and a 300-ton cyanide plant. The St. Paul-Montana Mining Co., Maiden, Fergus County, Mont., started a 70-ton mill, leaching the oxidized ores and treating the sulphide ores containing tellurides by counter-current decantation. At Marysville, Mont., the Barnes-King Co. have installed a standard slimes plant with Dorr agitators and thickeners. They are now changing to fine grinding and continuous counter-current decantation.

In Canada, the Tough-Oakes mill at Kirkland Lake commenced operation in March, and is treating 100 tons per day. This is a highly developed cyanide plant for treating rich gold ore and embodies the results of the latest technical study. The mill is on a rocky, gently sloping hillside about 1000 ft. from the main shaft. From this shaft the ore is delivered along an inclined trestle by a self-dumping skip. An intermediate pocket permits the handling of ore from No. 3 shaft over the same trestle. The crusher station occupies a separate building connected with the cyanide plant by an overhead conveyor. The cyanide plant is built in the shape of a letter L, the eastern wing comprising the fine-ore bin, ball mill, tube mill and plates. The main building houses the tanks, pump and accessory apparatus. In the crusher station run-of-mine ore is reduced to 1¼-in. ring by two jaw-crushers, with intermediate elevating and screening. The crushed ore is delivered by belt to the fines-storage bin at the end of the fine-grinding department. From it push-feeders deliver to a short conveyor feeding the ball mill. The ball mill product is split between two duplex Dorr classifiers, each operating in closed circuit with a 5 by 20-ft. tube mill. An elevator and copper plates are provided, so arranged that the plates may be interposed between either tube mill and its classifier. The classifier overflow runs by gravity into a 30 by 10-ft. Dorr thickener. The overflow of this machine, constituting the pregnant solution, gravitates to a box containing canvas leaves for clarifying. From this a vacuum pump delivers the clear solution to a sump, from which it is drawn for precipitation by the zinc-dust system. Thickened pulp from the bottom of the 30 by 10-ft collector thickener is transferred by diaphragm pumps to three 16 by 12-ft. Dorr agitators operating continuously in series. The pulp from the third agitator gravitates to the first of four 28 by 10-ft. Dorr thickeners, operating on the continuous counter-current decantation principle. Each tank is 24 in. higher than the preceding one. The overflow runs by gravity, while the thickened pulp transfers are effected by diaphragm pumps. From the final tank the thickened pulp is discharged by spigot into a launder, whence it runs through a mechanical sampling device and then to waste. A very interesting and complete article by John A. Baker[1] describes the building of this plant and gives detailed costs of all construction. The Cobalt Reduction Co., at Cobalt, finished their 300-ton concentrator and 175-ton cyanide plant for the treatment of the slimes. The slimes plant is equipped with Dorr agitators, classifiers and thickeners and Butters filter. The Schumacker Mine, Schumacker, Ont., began operation in their 150-ton counter-current cyanide plant in the latter part of the year. In the Porcupine district the Hollinger plant increased its capacity by adding more counter-current equipment. They are now operating one part of the mill separating the

[1] *Eng. Min. Jour.*, **100,** 915.

colloids and filtering them, and running the granular material by counter-current decantation alone, while the other part of the mill treats the whole product by straight counter-current decantation. There does not seem to much difference in the recovery by the two methods. The Dome mill has increased its capacity but with no change in metallurgy. The Miracle 50-ton mill and cyanide plant has been completed and the McIntyre-Porcupine plant changed over to counter-current decantation and is now doubling its equipment.

In Alaska the beginning of the operation of the Alaska Gastineau mill is probably the most interesting new undertaking of the past year, both on account of the magnitude of the plant and the radical departure from standard practice in gold milling. This plant has been designed along the lines used in concentrating the low-grade porphyry copper ores in Utah and Arizona. The ore is dumped from the mine cars over a grizzly, and the oversize is broken in jaw-crushers. The product from the jaw-crushers joins the undersize from the grizzly and is further reduced in gyratory crushers, all the product being reduced to 2-in. size. This is followed by roll crushing in Garfield rolls of 72 in. and 54 in. with intermediate screening through 10-mesh cloth on impact screens. Concentration begins on Garfield roughing-tables and is continued on Wilfley tables. The discard is classified and the coarser portion is reground in tube mills and the concentration repeated. The high-grade concentrates are amalgamated and finally melted into base bullion at the plant. The lower grade concentrates are shipped to outside reduction works. The mill is at present treating 10,000 tons per day and when all construction is finished will ultimately handle 20,000 tons per day. The mill heads average around $1.15 per ton with a recovery of $0.93 per ton. The Alaska Juneau Co. are constructing an 8000-ton plant along the same lines as the Alaska Gastineau mill.

There has been the usual number of articles published during the year dealing with milling practice at various plant and with chemical and metallurgical problems related to milling.

"Flotation Replaces Cyanide" by R. W. Smith[1] is an interesting and complete account of the Oneida Stag mill in Clear Creek County, Colo., in which flotation was advantageously used for the treatment of concentration tailing which had formerly been cyanided. The ore contains gold and silver in pyrite, gray copper, chalcopyrite and a little galena. In the mill as originally built the ore was crushed to 8-mesh by stamps, concentrated on Card tables, the sands discharged to waste and the slimes cyanided. This treatment gave 92 per cent. extraction at a cost of 80 cts. per ton for the cyanide treatment alone. The total mill feed

[1] *Eng. Min. Jour.*, **101,** 142.

was 50 tons per day and the slimes that were cyanided amounted to only 20 tons. The operators found that they could make more money by letting the cyanide department of the mill stand idle and saving only 65 per cent. of the value of the ore in the concentration department. After careful experiments the cyanide part of the mill was replaced by flotation as shown in the second flow sheet in Fig. 1. The coarse sand from the table tailings is removed and goes to waste as it contains almost no gold or silver. The slimes are dewatered in a Dorr thickener and treated in an eight-cell flotation machine with mechanical agitation.

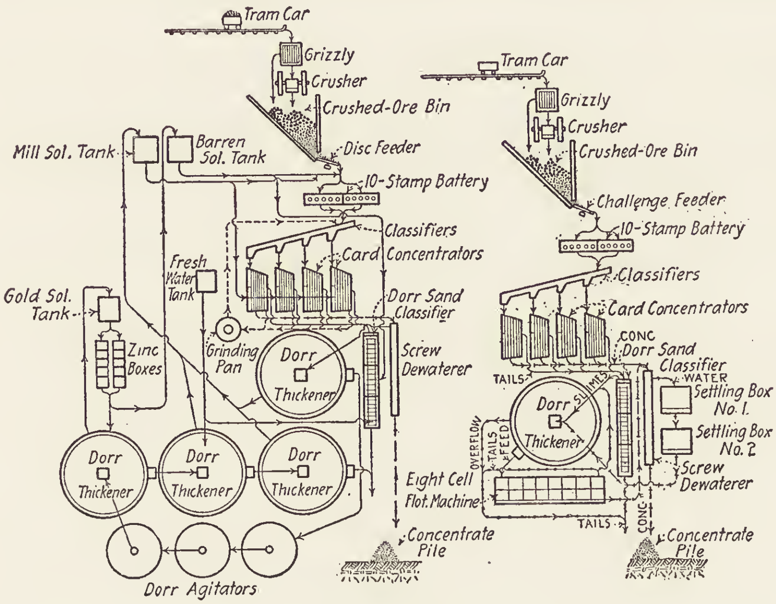


FIG. 1.—Flow sheet of the Oneida Stag Mill cyanide plant and the flotation plant into which it was changed.

Flotation costs 35 cts. per ton of mill feed, a saving of 45 cts. over cyanide which represents the profit obtained by using flotation.

Discussion of the appreciation of flotation in other mills will be found in the special article on flotation later in this volume.

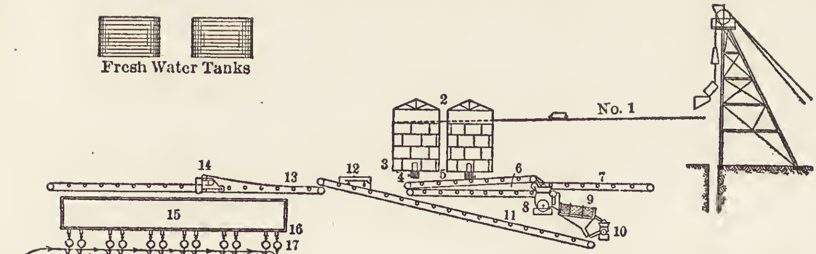
The Piegan-Gloster cyanide mill at Marysville, Mont., is described by Alexander McLaren.[1] The ore is delivered to the mill by aerial tramway, crushed in a No. 5 Smith short-head crusher to pass a 1¼-in. ring, elevated to an automatic sampler and distributed by conveyor to the mill bin. Thence it is fed to three Lane slow-speed Chilean mills where it is ground in cyanide solution. The consistency of the pulp is

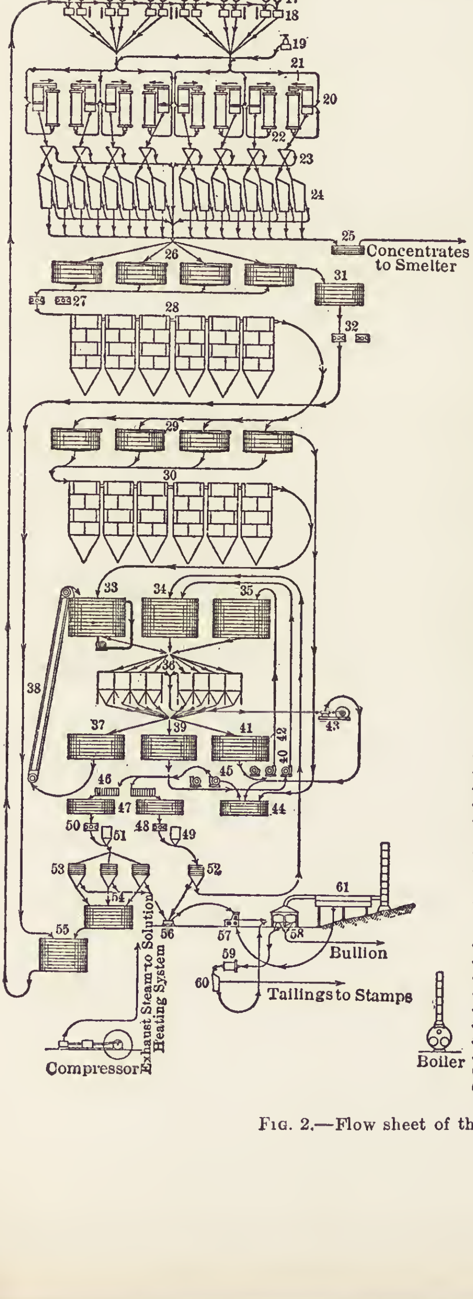
[1] *Eng. Min. Jour.*, **100**, 177.

4½ parts of solution to 1 of solids. From the mills the ground pulp passes to Wilfley tables. The concentrates consist of black sand and some coarse gold and are treated by amalgamation in a clean-up pan. The overflow from the tables goes to an Akins classifier for further separation. The sands proceed to leaching tanks. The slimes are taken to a 24 by 7-ft. Dorr thickener, from which the thickened pulp is transferred to Dorr agitators, worked on the change method. Zinc shavings are used for precipitation. Ore treatment at the Big Pine mine at Manhattan, Nev., is described by P. J. Quinn.[1] The ore is soft schist and the gold is all free. The ore is crushed by a 10 by 16-in. Blake crusher and elevated to a screen with 1-in. square openings. The oversize is considered waste; the undersize drops to the mill bin whence it is fed to a 5 by 20-ft. tube mill. Attached to the discharge end of the tube mill is a trommel of 6-mesh screen. The material which passes through this trommel—more than 99 per cent. of the pulp—is distributed over three amalgamating plates. At the bottom of each plate is a trap through which the pulp passes to Frenier pump and is elevated to a Dorr simplex-classifier, the coarse going back to the tube mill and the overflow over blankets to the tailings pond. Local pebbles are used in the tube mill. The Rainbow mill in eastern Oregon is described by W. M. Dake, Jr.[2] The ore passes over a grizzly with ¾-in. openings to a Blake crusher and thence to fifteen 1050-lb. stamps which crush it, in cyanide solution, to pass 4-mesh screens; it is then elevated into a 5-ft. cone, the overflow from which goes to a Dorr thickener, the underflow to a Dorr classifier, the sand discharge from the classifier goes to a 5 by 22-ft. tube mill. The hard dike material from the mine is used instead of flint pebbles in the tube mill. The discharge from the tube mill runs over amalgamating plates which are in a closed circut with the classifier and tube mill. The underflow from the thickener goes to three 12 by 30-ft. Pachuca agitators arranged for intermittent agitation, thence to a Parral-type Kelly filter. Precipitation is by the Merrill zinc-dust process.

The Tonopah plant of the Belmont Milling Co. is described in detail with construction and operating costs by A. H. Jones.[3] The ore is broken underground to pass a 9-in. grizzly; from the shaft it goes to two circular steel crusher pockets with a combined capacity of 1000 tons whence it is fed over shaking grizzlies with 2-in. openings, the oversize going to a picking belt where waste is removed by ore sorters. The picking belt discharges over a shaking feeder to a No. 7½ K gyratory crusher set at 2-in. ring. The discharge from this crusher with the undersize from the crusher pockets goes to a 48-in. by 14-ft. trommel with

[1] *Min. Sci. Press*, **111**, 320.
[2] *Eng. Min. Jour.*, **99**, 1107.
[3] *Bull. Amer. Inst. Min. Eng.*, Aug., 1915.





Crushing and Conveying Plant

1. Hunt automatic railway.
2. Two circular steel crusher bins.
3. Two finger gates.
4. Two shaking grizzlies.
5. Steel apron picking belt.
6. Belt conveyor, undersize ore to trommel.
7. Belt conveyor for waste.
8. No. 7½K crusher.
9. 48 in. by 14 ft. trommel.
10. Two No. 4K crushers.
11. Conveyor to battery bins.
12. Electric weighing machine.

Mill

13. Distributing conveyor over battery bins
14. Automatic tripper.
15. Battery bins.
16. Twelve ore gates.
17. Twelve Challenge feeders.
18. Sixty 1,250-lb. stamps.
19. Lime grinder.
20. Eight duplex Dorr classifiers.
21. Eight flight conveyors.
22. Eight 5 by 18 ft. tube mills.
23. Eight 5-ft. Callow cones.
24. Sixteen No. 6 Wilfley tables.
25. Concentrates drying tank.
26. Four Dorr thickeners.
27. Slime pumps.
28. First battery tall agitation tanks.
29. Four Dorr thickeners.
30. Second battery tall agitation tanks.
31. Circulating-solution tank.
32. Circulating pump.
33. Filter stock tank.
34. Filter solution-wash tank.
35. Filter water-wash tank.
36. Filter boxes.
37. Surplus pulp tank.
38. Surplus pulp elevator.
39. Surplus solution-wash tank.
40. Surplus solution pump.
41. Surplus water-wash tank.
42. Surplus water-wash pump.
43. Vacuum pump.
44. Press-solution tank.
45. Clarifying-press pumps.
46. Clarifying presses.
47. Gold tanks.
48. Solution pump to complete-precipitation press.
49. Zinc-dust feeder for complete precipitation
50. Solution pump to partial-precipitation presses.
51. Zinc-dust feeder for partial precipitation.

Refinery

52. Merrill press for complete precipitation.
53. Merrill presses for partial precipitation.
54. Partial precipitated solution tank.
55. Battery storage tank.
56. Steam drying car for precipitate.
57. Briquetting machine.
58. Melting furnaces.
59. Tube mill for slags.
60. Concentrating table for slags.
61. Dust chamber and stack.

Fig. 2.—Flow sheet of the Belmont mill.

1¼-in. openings; the oversize goes to two No. 4D short-head gyratory crushers set to 1-in. ring; the discharge from these crushers with the undersize from the trommel is carried to the head of the mill on a 20-in. belt conveyor, being automatically weighed by an electric machine while on the belt. The ore is distributed to the battery bins of 1500 tons capacity by another belt conveyor with automatic tripper, there is an automatic sampling device between the conveyor from the crushing department and that which distributes the ore to the battery bins. The ore from the battery bins is fed through Challenge feeders to sixty 1250-lb. stamps which crush through 4- and 6-mesh Tyler "ton-cap" screens. Crushing is done in solution carrying about 5 lb. cyanide and 1 lb. lime. The stamp duty has averaged 8.88 tons per day. The battery discharge is delivered to eight Dorr duplex classifiers, which are in closed circuit with eight 5 by 18-ft. tube mills. The overflow from the Dorr classifiers, or the finished product from the tube mills flows to eight 5-ft. Callow cones, the overflow from which goes direct to the Dorr thickeners while the spigot drainage is treated on 16 No. 6 Wilfley tables which make a clean concentrate, but not a close concentration. The pulp from the Wilfley tables and the overflow from the Callow cones flow to four 30 by 12-ft. Dorr thickeners, two of which are equipped with settling trays. The overflow from these thickeners flows either to the circulating tank or the precipitation supply tanks. The underflow, at about 1.26 specific gravity, is pumped to the first of a series of six air agitators of the Pachuca type, 15 ft. by 45 ft. with 55° cone, with a capacity of 6000 cu. ft. An air lift delivers the pulp from the agitators to a system of launders where it is diluted with partly precipitated solutions, goes to four Dorr thickeners and thence to the second battery of six agitators, the overflow from the thickeners goes to the precipitation supply tanks. Filtering is accomplished by a 250-leaf vacuum-filter plant, constructed on the half-gravity system. Pregnant solution is pumped through three Merrill clarifying presses and after the zinc dust has been added through Merrill triangular presses in the refinery. The product is briquetted with fluxes and melted in two double-compartment, carborundum-lined Rockwell furnaces. Electric motors are used throughout the mill, the average power consumption is 1.68 hp. per ton milled. The total milling cost is $2.156 per ton, divided as follows: labor, $0.419; supplies, $1.318; power, $0.419.

The cyanide plant of the Corinthian North mine in the Yilgarn district is fully described with working costs in an article on "Cyanidation in Western Australia" by V. F. Stanley Low.[1] The ore after passing over the grizzly and through a 11 by 22-in. jaw crusher drops into a storage bin from which it is delivered by Challenge feeders to the 20-stamp

[1] *Min. Sci. Press*, **111**, 81.

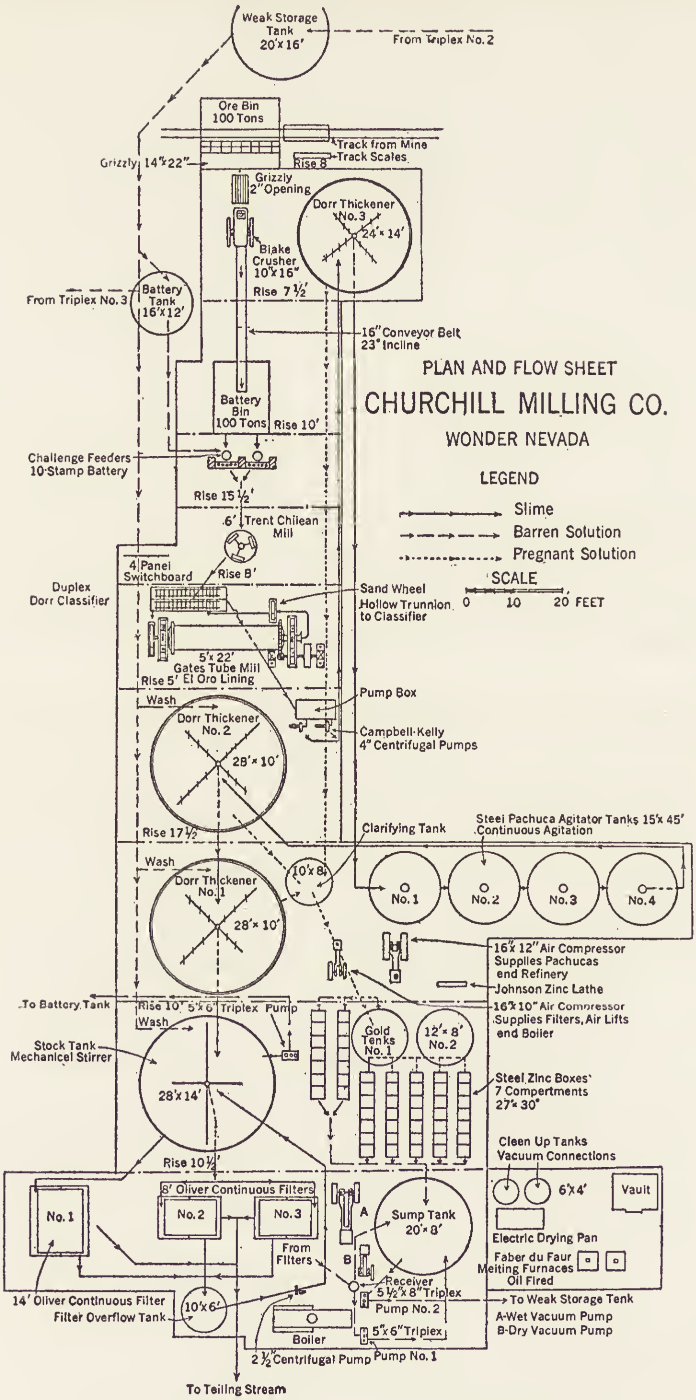


Fig. 3.—Flow sheet of the cyanide plant, Churchill Milling Co.

battery. The stamps weigh 150 lb. and the mortars are of the Homestake type with screens of 6- or 10-mesh; the average duty is 10 or 11 tons per 24 hr. Crushing is done in solution. The pulp from the stamps is pumped to two cone-separators 6 ft. in diam. and 7½ ft. deep. The overflow from these cones passes through two 25-ft. Dorr type thickeners to four 18 by 8-ft. Dorr type agitators. The underflow from the cones goes to two 4 ft. 1 in. by 16-ft. tube mills in closed circuit with the cones. After agitation the pulp is pumped to two Ridgway filters and the pregnant solution goes to ordinary zinc boxes. Jesse Simmons describes the practice of the Trojan Mining Co. in the Black Hills.[1] The ore is crushed in a Chilean mill in cyanide solution, the product being divided into 45 per cent. sand and 55 per cent. slime in classifiers. The sand is given a simple leaching; the slime is reduced to 55 per cent. moisture in a thickener, then after 12 hr. of agitation in a conical bottom tank it receives final treatment in a filter.

E. E. Carpenter describes the mill and practice of the Churchill Milling Co., Wonder, Nev.[2] The ore is unusually hard and tough but breaks well under the stamps. After passing the Blake crusher it is crushed by ten 1400-lb. stamps through screens with ⅜-in. square openings and then by a 6-ft. Chilean mill with a No. 693 "ton-cap" screen. Following the Chilean mill and in closed circuit with a 5 by 22-ft. tube mill is a Dorr classifier, the overflow from which is pumped to a Dorr thickener, the overflow from which goes to the gold tanks and the thickened pulp to the first of a series of four Pachuca agitators. Oliver filters are used and precipitation is by zinc shavings. The precipitates are refined without acid treatment. Complete data as to costs and results are given.

In "Cyanidation of Low-grade Sulphide Ores in Colorado"[3] H. C. Parmelee described the Argo mill in Clear Creek County and the Cariman mill at Caribou in Boulder County. The former mill has already been described in the Mineral Industry, **23**, 357 (1914). The Cariman mill was built for the treatment of the low-grade silver ores of Caribou from the dumps and old stope fillings of the mines of that district. Concentration followed by leaching the sands and agitating the slimes results in a gross extraction of 85.8 per cent. of the silver at a total milling cost of $1.72 per ton. Jay A. Carpenter, in an article on "Slime Agitation and Solution Replacement Methods at the West End Mill"[4] deals with the use of the Trent agitator as a replacement machine. Detailed accounts of various experiments with this machine and tables showing re-

[1] *Min. Sci. Press*, **111**, 707.
[2] *Bull. Amer. Inst. Min. Eng.*, June, 1915
[3] *Met. Chem. Eng.*, **13**, 421, 477.
[4] *Bull. Amer. Inst. Min. Eng.*, Aug., 1915

sults are given. While the results obtained were not conclusive, the author believes that, with modifications, the replacer will become an accepted machine in the treatment of slime that is not too colloidal in its nature.

A brief description of the Las Vacas cyanide mill is given by E. David Pope.[1] This company is operating a 10-stamp mill, crushing to 30-mesh, with inside and outside amalgamation. The pulp passes to a Dorr simplex classifier, which is in closed circuit with a 3-ft. tube mill and amalgamating tables. From the classifier the pulp, 87 per cent. passing 200-mesh, proceeds to a Dorr thickener and thence to Pachuca tanks and a Moore filter plant. Agitation in 0.1 per cent. cyanide solution for 12 hr. is sufficient to dissolve the gold. The tailing from the filter carries to the dump an average of 0.5 gm. Cyanide consumption is high. Of the gold 65 per cent. is extracted by amalgamation and a total recovery of 96 per cent. is obtained. The mill, when working at full capacity, is capable of treating 40 tons in 24 hr. In a paper read before the second Pan-American Scientific Congress W. M. Brodie gives an interesting account of ancient and modern "Metallurgy of Native-silver Ores of Southwestern Chihuahua."[2] The rich ores are treated separately in amalgamating pans and cyanided. The low-grade ores are concentrated, amalgamated and leached with cyanide by percolation. "Notes on Homestake Metallurgy," by Allan J. Clark[3] gives an account of operations at the plant up to date and supplements the previous article on the metallurgy of the ore by Clark and Sharwood.[4] It contains a complete description of the advances made as well as tables of costs. Electric drive, now in use for nearly 2 years, permits more nearly continuous operation than formerly. The flow-sheet shown in Fig. 4 gives an idea of the present arrangement.

Charles W. De Witt describes the Yangdegi mill of the Chicksan mines, Korea,[5] where gold ore running about $7 per ton is treated by amalgamation and cyanidation. After passing Blake crushers and grizzlies the ore goes to forty-five 1250-lb. stamps where it is crushed to 30-mesh and is then run over amalgamating plates, inside amalgamation being also used. The tailing from the plates runs to 16 Standard concentrating tables, eight of which act as roughers, the middlings from them going to the other eight. The concentrates are shipped to the United States for treatment. The tailing from the tables goes to an Akins-type deslimer. The slimes go to settling ponds where they are stored for possible future treatment. The sands are leached and the gold precipitated on zinc

[1] *Min. Mag.*, **13,** 33.
[2] *Eng. Min. Jour.*, **101,** 297.
[3] *Bull. Amer. Inst. Min. Eng.*, July, 1915.
[4] *Trans. Inst. Min. Met.*, **22,** 68.
[5] *Bull. Amer. Inst. Min. Eng.*, May, 1915.

shavings. Steam power is used. The milling cost is $0.67 per ton and the cyaniding cost $0.335.

"Metallurgical Practice in the Witwatersrand District, South Africa," is treated in an interesting article by F. L. Bosqui.[1] The evolution of

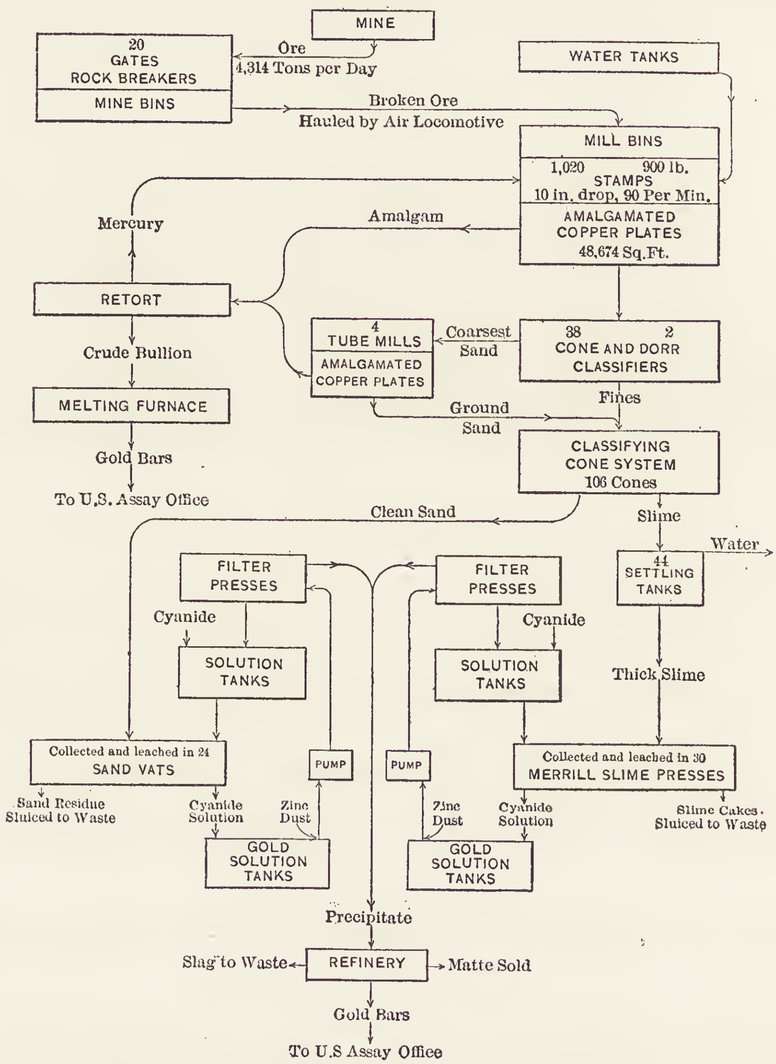


FIG. 4.—Flow sheet showing ore treatment at Homestake mine.

cyanide practice on the Rand is given historically and all departments of the present-day plant are described at length. The reasons for de-

[1] *Bull. Amer. Inst. Min. Eng.*, **52**, 931.

velopment of milling progress along local lines with little regard for standard practice in other mining fields is ably set forth. The flow-sheet of the proposed new reduction works of the Rand Mines, Ltd. (Fig. 6) shows the trend of the present metallurgical practice. Another

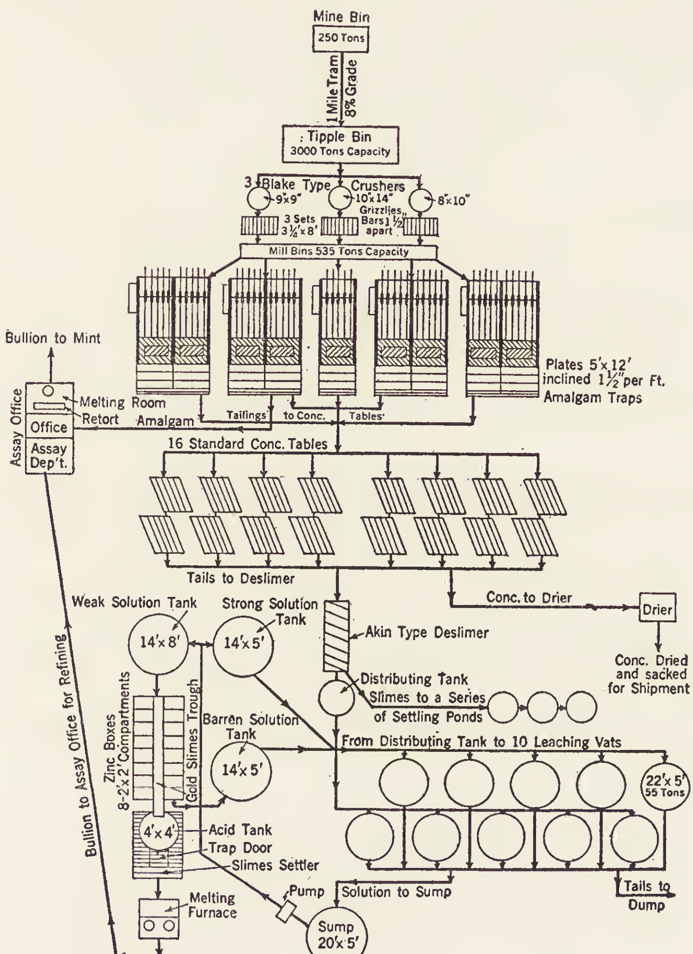


FIG. 5.—Flow sheet of the Yandei reduction plant of the Chiksan Co.

interesting review of recent changes in metallurgical practice in this district is given in an article entitled "Recent Rand Metallurgical Practice," by N. Thornton Murray.[1]

The attention that has been given to the chemical advances in

Eng. Min. Jour., **99**, 771.

cyanide practice is covered in a paper by J. E. Clennell on "Recent Advances in the Chemistry of Cyanogen Compounds."[1] The author divides his paper into two parts: first, the advances in the chemistry of ore treatment by cyanide; second, the advances in the manufacture of cyanide compounds. In the first part he takes up the treatment of carboniferous ores and products, electrolytic regeneration of cyanide and the effect of mineral ingredients in water on cyanide consumption. In the second he discusses the problems of fixation of atmospheric nitrogen, conversion of cyanimides into cyanides, production of cyanogen compounds from nitrogenous gases by catalysis and otherwise and the production of cyanogen compounds from gaseous mixtures by absorption with a metallic salt. A very complete bibliography is given.

"The Hydrometallurgical Treatment of Complex Gold and Silver Ores"[2] is an elaborate paper by G. H. Clevenger. After a careful historical sketch the author discusses preliminary or accessory operations and then deals with the important factors in the operation of the cyanide process. Examples are given from different plants, showing the gradual evolution of present-day practice. Several proposals of special ore treatment are added.

The results of a number of experiments made to determine the "Influence of Heat in Cyaniding Gold Ores" is given by E .A. Wraight.[3] Summing up the results of his experiments the writer makes the following deductions:

1. The effect of heating cyanide solutions is of very doubtful benefit; the extraction may be increased for a short period, but this is more than compensated by the increased cyanide consumption and the subsequent decrease in the rate of dissolution of gold.

2. Oxidizing agents (H_2O_2 excepted) are apparently of no value and may even exercise a deleterious effect on the extraction.

3. The addition of oxygen in a more active form, either as hydrogen peroxide or by means of heated air, increases the solvent activity of cyanide solutions in a very pronounced manner.

"Clay: Its Relation to Ore Dressing and Cyaniding Operations" is the title of a long and interesting paper by A. W. Allen.[4] After discussing various theories and citing many examples from actual practice, the author concludes: Adsorption of gold solution may occur during treatment, but the main loss is probably due to absorption. This conclusion is strengthened by the fact that (*a*) non-colloidal clay is only slightly absorbent, (*b*) colloidal clay is highly absorbent, (*c*) burnt clay

[1] *Bull. Amer. Inst. Min. Eng.*, Oct., 1915.
[2] *Met. Chem. Eng.*, **14,** 230.
[3] *Inst. Min. Met. Bull.*, **136.**
[4] *Inst. Min. Met. Bull.*, **135.**

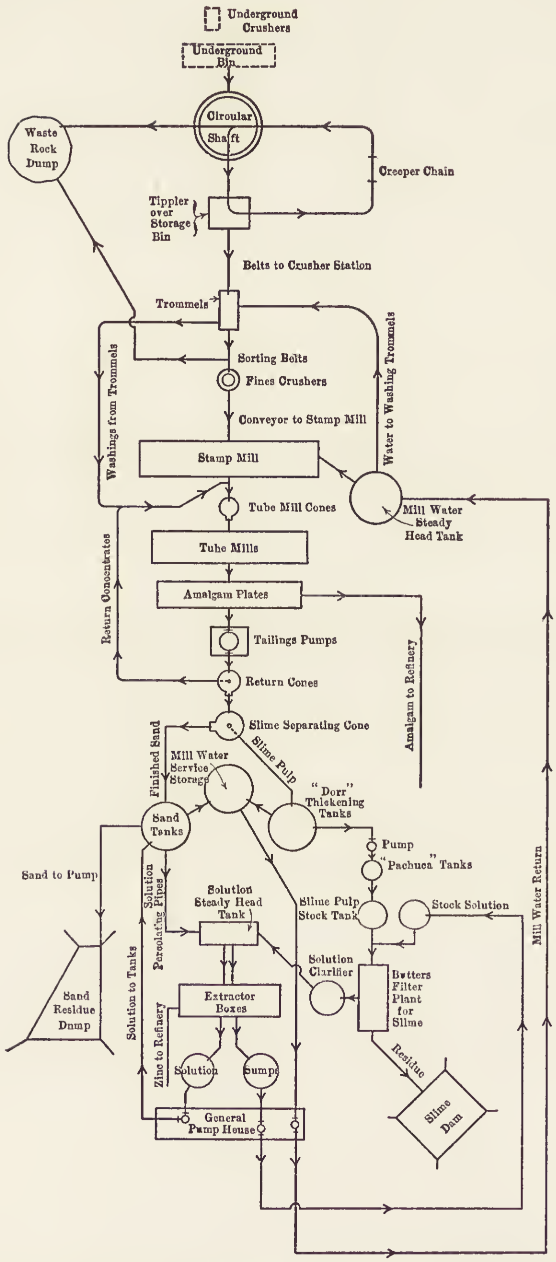


FIG. 6.—Flow sheet, proposed new reduction works, Rand Mines, Ltd.

(*i.e.*, after the colloidal envelop has been destroyed) is practically non-absorbent. "The Prevention of Hydrolysis in Cyanide Solutions" by H. M. Leslie[1] gives a description of experiments showing a saving in cyanide by a "closed system." "Cyanide Consumption on the Witwatersrand" by H. A. White[2] is a discussion of the various causes of cyanide loss in operating plants. "The Effect of Mineralized Water in Cyanide Plants" by Thomas B. Stevens and W. S. Bradley[3] describes the methods used with "salt" water in western Australia. "Precipitating Action of Carbon in Cyanide Solutions" by W. R. Feldtmann[4] gives a series of experiments with a graphitic West African ore; it is discussed at length by W. B. Blyth and others.[5] "The Morro Velho Method of Assay of Gold Bearing Cyanide Solutions" is described by Donald M. Ley and Harold Jones.[6]

"The Relative Efficiency of Various Amalgams in the Recovery of Gold" by Francis A. Thompson and Robert Keffer[7] gives a description of a series of tests run with silver, gold, sodium, tin, lead, zinc, and cadmium amalgams and plain mercury on copper plates. From the tests it appears that mercury has a greater affinity for gold when pure than when any other metal is amalgamated with it. When an amalgam shows a higher extraction than mercury alone, the effect is not caused by any increased efficiency due to the presence of the foreign metal; but rather to the superior resistance of the amalgam to the effects of impurities. Cadmium amalgam leads in the quality of remaining bright and clean in the presence of sulphates.

E. M. Hamilton and P. H. Crawford describe in detail a new and commercial method of precipitating gold and silver by aluminium dust.[8] Jay A. Carpenter[9] defends the use of zinc shaving as a precipitant in cyanidation. Some of his arguments against zinc dust are refused by Donald F. Irvin.[10] "The Liberty Bell Methods of Precipitate Refining" by A. J. Wenig[11] describes a series of experiments which led to the abandonment of acid refining and the adoption of refining by fusion. E. M. Hamilton discusses "Aluminium Precipitation at Nipissing"[12] showing the difficulties encountered with zinc and the economies resulting from the use of aluminium. G. H. Clevenger[13] tells of the use of aluminium dust as a substitute for zinc in cyanidation and also treats on

[1] *Jour. Chem. Met. Min. Soc. So. Afr.*, **16**, 36.
[2] *Jour. Chem. Met. Min. Soc. So. Afr.*, **16**, 24.
[3] *Inst. Min. Met. Bull.*, **127**.
[4] *Inst. Min. Met. Bull.*, **127**.
[5] *Inst. Min. Met. Bulls.*, **128**, **130**, **132**.
[6] *Inst. Min. Mt. Bull.*, **128**.
[7] *Met. Chem. Eng.*, **13**, 367.
[8] *Min. Sci. Press*, **111**, 3870.
[9] *Min. Sci. Press*, **111**, 888.
[10] *Min. Sci. Press*, **112**, 115.
[11] *Bull. Amer. Inst. Min. Eng.*, Mar., 1916.
[12] *Eng. Min. Jour.*, **99**, 568.
[13] *Min. Sci. Press*, **112**, 118.

its use in making explosives. Douglas Lay, in "Gold Precipitation on Paper"[1] describes a method of electrolytic precipitation for use with cyanide solutions in which the gold is deposited on a paper cathode which can be burned away as the gold is melted without contaminating it. G. H. Clevenger's paper on "Electrolytic Precipitation of Gold Silver and Copper from Cyanide Solutions"[2] discusses the possibility of using electricity to replace zinc and aluminium precipitation and is of especial interest at this time in view of the high prices of those metals. "Refining Cyanide Precipitates" is discussed by H. T. Durant[3] who points out the faults of ordinary methods and shows how they may be improved. An historical sketch on "Refining Gold Bullion" is given by Sir Thomas Kirke Rose.[4] An interesting description of "Clean-up Room Practice at the Simmer Deep" is given in a paper by W. H. Jane and E. Davey.[5]

An "Electric Furnace for Gold Refining at the Alaska-Treadwell Cyanide Plant" is described by W. P. Lass.[6] A single-phase electric furnace has been substituted for a blast furnace for treating the slag, matte, flue dust, etc., from the refinery. He gives complete details of the furnace and its operation. The furnace has a melting chamber 14 in. in diam. by 20 in. high. It is operated on a 11-volt, 60-cycle lighting circuit, starting a run as an arc type and finishing as a resistance type furnace. The advantages of the electric furnace as compared to the blast furnace for melting high-grade gold slags are: A saving in mechanical loss of gold in flue dust, because the melting is done in a quiet neutral atmosphere instead of in a rising blast of air; the obtaining of a lower grade slag, free from shot, by reason of the quieter melting action and the higher temperature obtainable, making a more fluid slag; the nicety of regulation of the melting temperature; the benefit to the general health of the operators. Regis Chauvenet[7] discusses the blast-furnace smelting of cupiferous cyanide precipitate. He deals with the effect of zinc in slags and gives the solution of two problems. In the first, no matte is formed in smelting, in the second, matte is formed. He finally discusses the impossibility of forming both matte and slag of assigned composition.

An article on "The Theory of Tube Milling" by H. A. White[8] gives the results of a large number of experiments made in the laboratory of the South African School of Mines and Technology. It gives tables showing:

[1] *Eng. Min. Jour.*, **100**, 276.
[2] *Trans. Amer. Electrochem. Soc.*, **28**, 263.
[3] *Eng. Min. Jour.*, **100**, 523.
[4] *Inst. Min. Met. Bull.*, **127**.
[5] *Jour. Chem., Met. Min. Soc. So. Afr.*, **16**, 67.
[6] *Bull. Amer. Inst. Min. Eng.*, July, 1915.
[7] *Met. Chem. Eng.*, **14**, 96.
[8] *Jour. Chem., Met. Min. Soc. So. Afr.*, **15**, 176.

1. Diameters and revolutions per minute to make layers of pebbles continuous.

2. Variations in power with load constant at various speeds.

3. Revolutions per minute corresponding with maximum horsepower for various loads.

4. Theoretical maxima of pebble lifting horsepower for standard tube mill with various loads.

5. Theoretical discharge diameters.

6. Observed discharge diameters.

7. Height of fall of pebbles to break particles of banket.

8. Fluctuations in fall of pebbles, revolutions per minute steady.

9. Variation in speed during one revolution of tube.

This very complete article is discussed by various engineers.[1] "The Position of the Tube Mill in the Mill Circuit" is shown in an article by Algernon Del Mar.[1] Fourteen different arrangements of the tube mill in the flow-sheet of a stamp mill are discussed. The best combination depends on the ore to be treated. "Ore Treatment at Cripple Creek: A Review," by P. Henry Argall,[2] treats, in an historical sketch, of milling in the Cripple Creek district with a description of the process used at the Stratton Independence Mill under his management. "Ore Treatment in Korea"[3] describes the operation in the mill of the Oriental Consolidated Mining Co. Only 50 per cent. recovery of the gold is now being made but the work in the cyanide plant promises better recovery on the concentrates.

"Cyaniding of Gold-silver Ores at Waihai," Grand Junction, by Noel Carless,[4] gives a complete description of the work at this plant with costs and flow-sheet. "The Use of Scoop Discharge in Tube mills," by W. R. Dowling,[5] describes experiments to increase the capacity at Knights Deep and other mines on the Rand.

"Amalgamation in Hardinge Mills" is the subject of some interesting discussion. F. J. Girard raises some questions over contradictory results at the Plymouth and Incaoro mills.[6] Mr. Hardinge contributes some interesting comments and early history.[7] J. W. Pinder gives details of experience at the Curaren and Rosario mills,[8] and Geo. R. Pringle gives details of operation at Incaoro, Bolivia.[9]

[1] *Min. Sci. Press*, **111**, 130.
[3] *Min. Sci. Press*, **111**, 706.
[2] *Min. Sci. Press*, **110**, 256.
[4] *Bull. Inst. Min. Met.*, **127.**
[5] *Jour. Chem., Met. Min. Soc. So. Afr.*, **15**, 214.
[6] *Min. Sci. Press*, **110**, 110.
[7] *Min. Sci. Press*, **110**, 261.
[8] *Min. Sci. Press*, **110**, 338.
[9] *Min. Sci. Press*, **110**, 829.

COSTS OF MILLING

Detailed costs of milling have been published for the following properties: Hollinger mill, Porcupine, Ont.;[1] Lake View & Star mine, Australia;[2] Sons of Gwalia mine, Australia;[3] Wasp No. 2 mine, S. D.;[4] Crown Reserve mine, Cobalt, Ont.;[5] South Kalgurli mine, Australia;[6] Commonwealth mine, Ariz.;[7] Goldfield Consolidated mill, Nev.;[8] Brunswick Consolidated mill, Cal.;[9] West End mill, Tonopah;[10] Kuk San Dong mill, Korea.[11]

[1] *Min. Sci. Press*, **110**, 439.
[2] *Min. Sci. Press*, **110**, 447.
[3] *Min. Sci. Press*, **110**, 445.
[4] *Min. Sci. Press*, **110**, 524.
[5] *Min. Sci. Press*, **110**, 614.
[6] *Min. Sci. Press*, **110**, 802.
[7] *Min. Sci. Press*, **110**, 803.
[8] *Min. Sci. Press*, **110**, 879.
[9] *Min. Sci. Press*, **110**, 337.
[10] *Min. Sci. Press*, **111**, 248.
[11] *Min. Sci. Press*, **111**, 887.

GRAPHITE

By Benjamin L. Miller

The great European war affected the graphite industry in 1915 even more than in 1914, resulting in increased prices and greater production. Few mineral products are as international in character as graphite. In time of peace each country has felt the necessity of importing graphite from Ceylon, Korea, Madagascar, and Mexico, the material from each country peculiarly adapted to a specific purpose. With the interruption of ocean transportation various importing firms have been unable to maintain supplies of the different kinds for their customers and many local deposits have been required to make up the deficiency. Prices have fluctuated, in general steadily rising, and at times certain grades have been unobtainable at any price. Stable conditions can scarcely be expected until the close of the war.

Graphite in Foreign Countries

Canada.—As graphite is found in a number of places in the metamorphic rocks of Ontario and Quebec where at various times numerous mines have been opened, it was only natural to have increased activity in the graphite industry under the stimulus of the high prices prevailing during 1915. Several new operations were started.

The Bureau of Mines of Canada reports as follows concerning the graphite production during 1915:

"Shipments of milled and refined graphite amounted to 2610 tons valued at $121,023 or an average of $46.37 per ton. This includes 76 tons from mills at Buckingham, Que. The major portion of the production came from Calabogie, Renfrew County, Ont., with a small tonnage from Mumfords, Hastings County. The production includes material varying in value from less than $40 to over $150 per ton. The 1914 production was 1647 tons valued at $107,203. Operators report a greatly increased demand with higher prices owing to the shortage in supplies in the United States from sources outside of America.

"Exports of plumbago and of manufactures of plumbago were valued at $96,325 according to Customs records."

Ceylon.—The demand for Ceylon graphite by the crucible makers of the world was greater in 1915 than ever before because of the increased use of crucible steel for war purposes. With large war orders steel manufacturers became insistent for graphite crucibles in larger quantities than ever before with the result that Ceylon graphite steadily increased in price without materially increasing the amount obtainable. On Jan. 1, 1915 the best lump Ceylon graphite sold in New York for 9 cts. per lb., while on Jan. 1, 1916 it was selling at 20 cts. per lb. In April, 1916, it had still further increased to 27 cts. per lb. The increased price was in large measure due to the higher freight rates and higher rates of insurance. In some instances these amounted to more than 8 cts. per lb. In addition, many of the Ceylon graphite mines are being exhausted, the costs of mining are becoming greater with increase in depth on account of the timbering necessary and the large amount of water encountered, while the supply of labor has been deficient. At times during the year it was impossible to get vessels for the shipment of the graphite because of the demand for the transportation of war necessities by the Allies. Such a combination of circumstances resulting in an unprecedented demand for Ceylon graphite which could only in part be satisfied resulted in the abnormal prices that prevailed during the latter part of 1915 and the first part of 1916. As always happens when transportation charges become excessive, the lower-grade materials are not shipped and in 1915 the proportion of the best Ceylon lump to the lower-grade materials was considerably greater than in former years.

The embargo placed on Ceylon graphite by the British Government in 1914 to prevent any of it falling into the possession of the Central Powers was partially lifted in May, 1915, and entirely in the following September. In May the British Foreign Office "authorized the Governor of Ceylon to grant licenses for direct shipment of plumbago by regular shippers to regular customers in the United States, shipment to to be made through the British Consul General at New York. Such exportation is to be restricted to shipments through regular channels existing in normal times, and the British Consul General at New York has been instructed to make delivery only after actual sales to manufacturers and after the latter have given him duly signed guarantees, as required by the prescribed form of application."

Korea (Chosen).—The shortage in the world's graphite supply caused a greater demand for Korean material, yet the amount brought to the United States during 1915 was only a few thousand tons as vessels could not be obtained for its shipment. The price, which is normally about $25 a ton, increased to $45.

Madagascar.—The French Government placed an embargo on the exportation of Madagascar graphite to other countries than France in the fall of 1914, and while the order has been modified to permit shipment to neutral countries, yet the bulk of the island's graphite exports went to France during 1915. On Jan. 29, 1916, the American Consul at Taniatave sent the following report:

"The only feasible way in which any considerable amount of graphite may be obtained from Madagascar by importers in the United States would be on ships sent here for that purpose. It is possible to ship via Durban by the Messageries' ships and from that place to New York by the Union Castle Line; but the freight is 70 to 75 francs ($13.50 to $14.50) more per ton than by the usual Marseille route.

"At present large quantities of Madagascar graphite are in demand in France, and the steamship companies are doing everything possible to forward graphite shipments to that country. Two ships scheduled to leave Madagascar on or about Feb. 2 and 16, respectively, are wholly reserved for graphite intended for France, notwithstanding the fact that there are thousands of tons of other classes of merchandise congested at the different ports.

"Nearly all of the Madagascar graphite producers would appear to have at present contracts with large buying and export firms for the delivery of all of their product."

The price of Madagascar graphite increased from 50 to 100 per cent. during the year, selling for 12 cts. per lb. the latter part of 1915.

Mexico.—In spite of the continuation of the Mexican revolutions considerable graphite was exported from Mexico to the United States during 1915. The amount, however, was considerably less than in former years yet the world's supply for the manufacture of pencils continues to come from Mexico.

Graphite in the United States

Although the graphite produced in the United States is less satisfactory for the manufacture of crucibles than that obtained from Ceylon yet it is accepted as a substitute for the Ceylon product for many purposes. The increased prices stimulated increased activity and the production of flake graphite is reported to have been about 1,850,000 lb. in excess of the 1914 production. New companies were organized and new mines opened, some of which had not started operations at the close of the year, which will still further increase the output during 1916 if present conditions continue.

Alabama.—During 1915 there was more activity in graphite mining in Alabama than ever before, and in addition to the older companies several new ones were started. The Ashland region still continues to be the center of the industry. The main production was made by the Quenelda Graphite Co., located about 8 miles west of Ashland, the Ashland Graphite Co., located about 4½ miles west of Ashland, the Flaketown Graphite Co., located about 3½ miles northeast of Mountain Creek station, and the Jennings Graphite Co. near Lineville.

The Alabama graphite is all of the crystalline flake variety and when thoroughly cleaned is an excellent product. Its occurrence in metamorphic schists that are apt to contain mica introduces many problems in the milling process which, in some instances, have not been satisfactorily solved.

STATISTICS OF GRAPHITE IN THE UNITED STATES

Year.	Refined Crystalline Graphite.						Amorphous Graphite Production.	
	Production.		Imports.		Consumption. (a)			
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Tons, 2000 Lb.	Value.
1900	4,103,052	$164,122	32,298,560	$1,389,117	36,401,612	$1,553,239	1,045	$8,640
1901	3,967,612	135,914	32,029,760	895,010	36,997,372	1,067,921	809	31,800
1902	4,176,824	153,147	40,857,600	1,168,554	45,034,424	1,322,401	4,739	55,964
1903	4,525,700	164,247	32,012,000	1,207,700	36,537,700	1,371,947	16,591	71,384
1904	4,357,927	162,332	25,350,000	905,581	29,707,927	1,067,913	19,115	102,925
1905	4,260,656	170,426	34,914,611	983,034	39,175,267	1,153,460	21,953	80,639
1906	4,894,483	170,866	50,974,336	1,554,212	55,868,819	1,725,098	16,853	(b)
1907	4,586,149	149,548	40,962,000	1,777,389	45,548,149	1,926,937	26,962	138,381
1908	3,433,039	149,763	22,912,714	762,267	26,345,753	876,030	1,433	75,250
1909	5,669,899	340,194	42,532,851	1,854,459	48,202,750	2,194,653	5,096	32,238
1910	5,625,132	286,882	50,610,560	1,872,592	56,235,692	2,159,474	1,407	39,710
1911	4,790,000	256,050	41,404,000	1,495,729	46,194,000	1,751,779	1,223	32,415
1912	3,543,771	187,689	51,286,000	1,709,337	54,829,771	1,897,026	2,063	32,894
1913	5,064,727	254,328	57,758,400	2,109,791	62,823,127	2,364,119	2,243	39,482
1914	5,220,539	285,368	44,004,800	1,398,261	49,225,339	1,683,629	1,728	38,750
1915	7,074,370	417,273	46,150,000	2,241,163	53,224,370	2,658,436	1,115	12,358

(a) Neglecting the small re-export of foreign product. (b) Not reported.

Montana.—The Crystal Graphite Co. of Dillon, Mont., continued to produce during 1915 although the total output was inconsiderable.

New York.—The foremost place in the production of graphite is still retained by the State of New York, a position due to the extensive operation of the mine of the Joseph Dixon Crucible Co. located at Graphite, a few miles west of Lake George. For many years this has been the largest and most valuable graphite mine in the United States and in certain years it has been the only graphite mine in operation in the State. In 1915, however, two other companies, the Graphite Production Corporation of Saratoga Springs and the Popes Mills Graphite Co. of St. Lawrence Co. had small outputs.

In the former mine the ore is a metamorphosed graphite quartzite averaging about 6 per cent. graphite. The deposit is very regular so that a definite mining system can be employed, yet the success of this mine is due mainly to the careful management and should serve as an object lesson to the various graphite companies that have repeatedly opened mines and abandoned them without giving them a fair trial. The difficulties encountered are apt to be serious and numerous especially in the cleaning of the flake but that these are not insuperable barriers to success is well shown in the Dixon operations at Graphite.

Pennsylvania.—Mining was revived in the graphite district of Chester County, Pennsylvania where two companies were in operation. The principal production was made by the Graphite Products Co. Various plans for re-opening abandoned mines were formulated but most properties remained idle. In spite of the fact that graphite mining has been carried on for many years in Chester County it is nevertheless true that even yet no satisfactory test of the district has been made. Poor judgment in locating the proper place to open mines, unwise expenditure of money in equipment, lack of experience in management, and the tendency of the management to close down before necessary adjustments could be made are the principal reasons why few of the Pennsylvania graphite mines have proved to be profitable ventures.

Rhode Island.—The amorphous graphite deposits of Providence, R. I., were worked during 1915 about the same as in former years. The material is metamorphosed coal beds of Carboniferous age which, in part, has been altered to graphite. Its sole use is for foundry facings.

Manufactured or Artificial Graphite

The International Acheson Graphite Co. of Niagara Falls, N. Y., continues to be the sole producer of artificial graphite. The principal use for the product is for electrical purposes, electrodes, etc. During 1915 the demand for electrical supplies was very active and the production large.

PRODUCTION OF MANUFACTURED GRAPHITE 1899–1915

Year.	Quantity, Lb.	Value.	Price per Pound, Cents.
1899	405,870	$32,475	8.00
1900	860,750	68,860	8.00
1901	2,500,000	119,000	4.76
1902	2,358,828	110,700	4.69
1903	2,620,000	178,670	6.82
1904	3,248,000	217,000	6.70
1905	4,595,500	313,979	6.83
1906	4,868,000	312,764	6.42
1907	6,924,000	483,717	6.97
1908	7,385,511	502,667	6.80
1909	6,870,529	467,196	6.80
1910	13,149,000	945,000	7.19
1911	10,144,000	664,000	6.54
1912	12,896,347	830,193	6.44
1913	13,633,342	973,397	7.14
1914	10,455,139	698,800	6.68
1915	(a) 5,580,437	109,102	1.96

(a) Powdered graphite only; electrode material not included.

The Graphite Crucible Industry During 1915

Due to its highly refractory character and low ash-content graphite is eminently suited for the manufacture of crucibles and other articles that must be exposed to high temperatures and there seems to be a little doubt but that it there found its earlier use. It is believed that graphite crucibles were manufactured near Passau in Bavaria in the earliest part of the fifteenth century and were used by the alchemists of the Middle Ages.

WORLD'S PRODUCTION OF GRAPHITE
(In metric tons)

Year.	Austria.	Bavaria.	Canada.	Ceylon. (*a*)	India.	Italy.	Japan.	Mexico. (*b*)	Sweden.	United States. (*c*)	France and Colonies.
1900 .	33,663	9,248	1,743	19,168	1,859	9,720	94	2,561	84	1,799	....
1901 .	29,992	4,435	2,004	22,707	2,530	10,313	88	762	56	1,800	....
1902 .	29,527	5,023	993	25,593	4,648	9,210	97	1,434	63	1,895	....
1903 .	29,590	3,719	660	24,492	3,448	7,920	114	1,404	25	2,053	....
1904 .	28,620	3,784	410	26,478	2,955	9,765	216	970	55	2,045	....
1905 .	34,416	4,921	491	31,134	2,361	10,572	209	970	40	1,933	....
1906 .	38,117	4,055	405	36,578	2,642	10,805	177	3,915	37	2,220	....
1907 .	49,425	4,033	525	33,027	2,472	10,989	103	3,202	33	2,080	....
1908 .	44,425	4,844	227	26,227	2,919	12,914	177	1,076	66	1,557	300
1909 .	40,710	(*e*)4,900	783	25,995	3,182	11,583	284	1,704	26	5,875	320
1910 .	33,131	7,415	1,263	30,008	4,319	12,510	145	2,332	49	3,811	1,100
1911 .	41,599	11,298	1,154	27,433	4,114	12,621	114	2,974	65	3,280	1,870
1912 .	45,375	12,532	1,873	33,106	Nil.	13,170	149	2,865	79	3,318	5,600
1913 .	49,456	....	1,961	29,277	....	11,145	......	1,057	88	4,331	(*e*)7,000
1914 .	....	....	1,494	....	....	8,567	......	....	....	3,935	....
1915 .	....	....	2,368	....	....	....	......	....	....	4,280	....

(*a*) The figures for 1907, 1908, 1912 and 1913 are exports. (*b*) Exports. (*c*) Crystalline graphite up to 1909. (*d*) Includes the production of 7520 metric tons in Korea. (*e*) Estimated.

There is a difference of opinion among manufacturers regarding the best variety of graphite for crucibles. Some claim that Ceylon graphite alone is suitable for the best articles while others assert that flake graphite such as is produced in Pennsylvania is equally good, if not better. Those who favor Ceylon claim that it owes its desirable character to the fact that it breaks into foliated masses or thick rods rather than in thin flakes and when crushed is more even-grained. Also its greater purity is in its favor, Ceylon graphite often running 98 per cent. carbon while flake graphite of that purity can seldom be obtained. Those who contend that the flake graphite is preferable base their claims upon the greater toughness of the flakes and greater binding properties. Regardless of the relative merits of the two grades of materials both are used with satisfactory results. The bulk of the Ceylon graphite imported into this country is used in the manufacture of crucibles and has been imported for that purpose ever since 1829 when Joseph Dixon brought his first shipment of the Ceylon product to his crucible manufacturing plant, then located at Salem, Mass.

In the manufacture of crucibles the graphite owes its value to the fact that it does not fuse and also is a good conductor of heat. By experiment it has been shown that due to the ease with which the graphite conducts the heat from without the crucible to the metal within, much less fuel is consumed when graphite crucibles are used than when clay crucibles are employed. Time is also gained because the metal melts more quickly. Further, graphite crucibles can withstand sudden changes in temperature much better than clay crucibles. Downs[1] says "I have heated a small crucible to about 1400° C., and then suddenly plunged it into water, re-

[1] *Iron Age*, **65**, 5 (1900).

turned it to the fire and repeated it again and again until it had been shocked 20 times. If rung by striking it with the finger or a small bar, the crucible showed no change in the note of its ring until after the twelfth shock; by the time the twentieth was reached the note was nearly gone. In actual service, where the shock to which the crucible is subjected is not as sudden or severe as that just stated, a crucible has been known to stand from 80 to over 100 charges, though the average life is from 20 to 60 charges when used in melting copper alloys or equivalent metals.

"A list of the various kinds of work in which graphite crucibles are used as the melting pot includes malleable castings, small iron castings, crucible cast steel, all kinds of copper alloys (brass, etc.), spelter castings, file temperings, gold and silver melting and refining. Also oblong, square and round shapes are used in liquid brazing, and as calcining trays or boxes for materials requiring careful, even heating without exposure, such as pencil leads, incandescent light carbons, etc. One of the most interesting uses of the graphite crucible is that of a retort. The distillation of metals certainly requires special retorts if the metallic fumes are to be condensed and used. The best instance of the service is shown in the zinc distillation process now in use in all the silver refining works. Here the graphite retorts or bottles, are used in tilting furnaces and have a holding capacity of 1500 lb."

In the wide variety of uses of graphite crucibles naturally different ingredients are used and in varying proportions. The graphite itself possesses practically no binding strength and this property must come from substances mixed with the graphite. Clay, sand, and kaolin are the materials usually employed. The clay must be a high-grade fire-clay, with great plasticity, high percentage of combined moisture and extremely low in iron oxide, the alkalies, and alkali earths. Few clays produced in this country meet these requirements and hence most of the clay used in the manufacture of crucibles in the United States comes from Europe.

The sand used must be composed of practically pure silica (SiO_2), while the kaolin which is used for the purpose of influencing the fusibility of the mass must also be free from impurities, especially iron oxide.

Although the proportions of the materials vary according to the different purposes for which the crucibles are to be used it is said that most of them consist of about 3 parts of graphite, 2 parts of clay, 1 part of sand, and smaller amounts of kaolin. Analyses of crucibles used by crucible steel manufacturers show the following results:

Graphite	44 to 46 per cent.
Silica	34 to 38 per cent.
Alumina	15 to 17 per cent.
Iron oxide	1 to 3 per cent.

In the manufacture of the crucibles especial attention is given to the mixing of the ingredients. This is done in machines containing revolving arms that pass through the mass in different directions and the process is continued for a considerable length of time to insure a uniform distribution of the materials. A large amount of water is added to facilitate the process.

The crucibles are moulded as is ordinary pottery by machinery or by hand into various shapes and sizes according to demand. Usually the crucibles have the shape of an egg flattened at the broad end and truncated at the narrow end. Some are several feet in height and are made to hold over 1000 lb. of molten metal. The base is considerably thicker than the sides.

After being moulded the crucibles are carefully and slowly dried for a period of several weeks. Unless particular care is given to them during this stage many of them crack owing to the shrinkage of the clay. When thoroughly dry they are placed in kilns and burned in the same manner that pottery or brick are calcined. Not infrequently in the burning process some of the crucibles turn white on account of the graphite being burned out of the outer portions but it is only a thin film that loses the graphite and the value of the crucibles is not affected.

"The crucible manufacturers have been put to sore straits for the past 18 months in the securing of their raw materials.

"First came the embargo on Ceylon plumbago. This was lifted after a few months, but the market was left in a depleted condition. The natural result was a tremendous advance in price.

"Next came the exhaustion of the foreign clay which is used in crucible making as a binder. As far back as crucible history in this country goes the clay used has come from the little Principality of Klingenburg in the Black Forest of Southern Germany, where, so the story goes, the entire government expenses are paid out of the export duties collected from the clays shipped out. This Klingenburg clay has for years past been the only clay which the crucible makers seemed to think could be satisfactorily used. No shipments of this clay have been made since the beginning of 1915.

"Some makers have husbanded the enormous supplies of the foreign clay which they had on hand when hostilities started. This husbanding the stock of the now almost priceless raw material has been done by partially substituting clays from various parts of the United States and mixing them with the Klingenburg clay.

"The tests and trials made by the crucible makers during the past 12 months have been almost endless. When it is taken into consideration that it takes from 6 to 10 weeks to prepare a graphite crucible for service in the foundry, some idea can be formed of what the crucible maker has to contend with. Added to this delay and before he can even start on these goods that will not be marketable for 2 months to come, the chemical laboratory tests and trials must be made. These have run into the thousands. Then must come the practical tests in a small way in the foundry; for the crucible maker would stare bankruptcy in the face if he continued making up hundreds of thousands of dollars worth of goods out of Ceylon plumbago, costing from 17½ to 25 cts. per lb., only to find at the end of 2 or 3 months that they might not be of service to the user.

"The bright side, however, to all that is that in many cases the crucibles made with American clays have stood a surprisingly long time in the fires. In one case there is a report on a No. 300, which ran 40 heats on manganese bronze, and dozens of cases as high as 38 and 40 heats on No. 100's melting car box metal. The chief trouble now seems to be some lack in uniformity of the products secured. Crucibles made by the same potter out of similar materials, at the same time, and burnt in the same kiln, when run by one melter on the same grade of metals are liable to behave so differently from each other that it is a shock to both user and maker.

"All this will in time be rectified. As soon as the manufacturers have become more familiar with the mixing and blending of our native clays, they will no doubt be able to produce in time a crucible as satisfactory as or superior to those manufactured heretofore from foreign materials. The user, however, must use more care in handling the American clay crucibles.

"It is imperative that these crucibles are thoroughly dry and warm before going into the fire, and that they are heated up *very slowly* on the initial heat.

"Some users make a little fire with charcoal inside the crucible, and others put hot ashes in, before placing the pot in the fire, so that the crucible is hot when it goes into the fire for the first heat. There are certain advantages in heating the crucible first from the inside rather than the outside.

"Great care must be taken in the matter of wedging, as American clays have not the same tensile strength when hot, as foreign clay.

"The advance in prices of crucibles is due to the unusually high price of Ceylon plumbago just at present, but as soon as the war insurances are a thing of the past plumbago will be at a normal figure once more, and crucibles will again be marketed at as low prices or lower ones than they have been for many years past."[1]

[1] *Met. Chem. Eng.*, Mar. 1, 1916, pp. 287–288.

GYPSUM

By Frank A. Wilder

The gypsum industry is directly dependent on the building industry for its volume and prosperity. The greater part of the gypsum that is mined in America or imported from abroad is calcined for the manufacture of interior plasters. Of that which is sold crude, seven-eighths is used as retarder for Portland cement. The demand for crude gypsum, therefore, fluctuates with the economic conditions which govern construction activities and the curve follows closely that marking the demand for calcined plasters.

The earlier months of 1915 were months of depression in the building industry as compared with corresponding months before the war in 1914. Beginning with August, however, the comparison changes in favor of 1915, and this change is due to the poor showing made by the later months in 1914, as well as to the fact that by the fall of 1915 the building activities of the country had returned to normal, and during the last months of the year were 33 per cent. in excess of normal.

Taken as a whole therefore the gypsum industry for 1915 shows little change when compared with the year before, the main difference being that the periods of activity were just reversed. The quantity of gypsum quarried in the United States in 1915 was 2,447,611 short tons, valued at $6,596,893, about 1 per cent. less in quantity than that in 1914, and a decrease in value of about 4 per cent. New York led in the quantity mined, with 540,914 short tons, valued at $1,267,706; Iowa next, with 495,860 short tons, valued at $1,278,128; Michigan third, with 389,791 short tons, valued at $686,309; and Ohio fourth, with 259,036 short tons, valued at $772,520. Other producing States were Alaska, Arizona, Colorado, Montana, Nevada, New Mexico, Oregon, South Dakota, California, Kansas, Oklahoma, Texas, Utah, Virginia and Wyoming. In the canvass by the U. S. Geological Survey for the gypsum statistics in 1915 the State Geological Surveys of Illinois, Iowa, Michigan, Minnesota, Oregon, Virginia, Washington and Wisconsin co-operated with the Federal Survey.

The average price of raw and of calcined gypsum throughout the country decreased 9 cents a ton in 1915 from that of 1914. There were 77 active mines or quarries and 69 plants.

The importation of gypsum from Nova Scotia was unfavorably affected by the high ocean freight rates and the effect on the gypsum industry in Canada is shown in a paragraph on this subject below.

CRUDE GYPSUM MINED IN THE UNITED STATES (*a*)
(Tons of 2000 lb.)

1880	90,000	1892	256,259	1904	940,917
1881	85,000	1893	253,615	1905	1,043,202
1882	100,000	1894	239,312	1906	1,540,585
1883	90,000	1895	265,503	1907	1,751,748
1884	90,000	1896	224,254	1908	1,721,829
1885	90,405	1897	288,982	1909	2,252,785
1886	95,250	1898	291,638	1910	2,379,057
1887	95,000	1899	486,235	1911	2,323,970
1888	110,000	1900	594,462	1912	2,500,757
1889	267,769	1901	633,791	1913	2,599,506
1890	182,995	1902	816,478	1914	2,476,465
1891	208,126	1903	1,041,704	1915	2,447,611

(*a*) Statistics of the U. S. Geol. Surv.

PRODUCTION OF CRUDE GYPSUM IN THE PRINCIPAL COUNTRIES (*a*)
(In metric tons)

Year.	Algeria. (*b*)	Canada.	France. (*b*)	Germany. (*c*)		Greece.	India.	United Kingdom.	United States.
				Baden.	Bavaria.				
1898	37,337	198,864	2,115,261	28,037	25,688	83	8,390	199,174	285,644
1899	39,950	221,821	1,807,454	29,419	29,727	81	6,546	215,974	382,896
1900	42,237	228,656	1,774,492	26,381	35,484	129	4,415	211,436	439,265
1901	44,025	266,476	2,385,633	28,183	3,581	671	(*d*)	204,045	598,526
1902	44,975	301,165	2,185,346	33,150	31,701	*Nil.*	(*d*)	228,264	740,909
1903	41,550	285,242	1,998,804	29,423	30,894	94	(*d*)	223,426	945,281
1904	48,375	309,133	1,957,802	26,984	22,766	393	3,937	237,749	853,545
1905	34,743	395,341	1,378,145	28,823	46,247	185	4,877	259,596	982,626
1906	27,950	378,904	1,377,429	25,643	50,763	70	(*e*) 5,000	228,627	1,397,480
1907	26,400	431,286	1,316,567	29,153	48,975	70	(*e*) 5,000	239,285	1,564,061
1908	25,500	346,436	1,750,562	35,217	51,314	*Nil.*	(*e*) 5,000	231,980	1,694,155
1909	36,250	398,290	1,655,672	36,621	51,630	191	17,588	242,832	*f*)2,042,286
1910	60,625	481,941	1,980,804	41,078	54,397	249	13,759	259,648	*f*)2,158,756
1911	61,502	470,381	2,110,520	42,408	60,390	1,263	11,115	281,111	*f*)2,112,770
1912	(*d*)54,414	524,892	2,150,900	51,777	57,114	127	21,383	247,724	*f*)2,269,290
1913	50,413	577,442	1,726,379	49,767	....	2,245	25,362	242,341	*f*)2,357,752
1914	....	463,375	....	....	....	639	22,639	223,764	*f*)2,247,246
1915	....	426,730	....	....	....	....	....	207,983	*f*)2,220,458

(*a*) From official reports of the respective countries, except the statistics for the United States (*b*) A part of the product is reported as plaster of Paris. In converting this into crude gypsum it has been assumed that the loss by calcination is 20 per cent. (*c*) Prussia is a large producer of gypsum but there are no complete statistics available. The output in 1910 was 22,042 tons. (*d*) Statistic not available. (*e*) Estimated. (*f*) U. S. Geol. Surv.

Gypsum Production of Canada

The production of gypsum of all grades in 1915 is reported as 470,335 tons valued at $849,928. This is lower than for several years, previous production having been 516,880 tons in 1914; 636,370 tons in 1913; and 578,454 tons in 1912. The Ontario production was practically the same as in 1914, while in New Brunswick production showed a slight increase. In both Manitoba and Nova Scotia 1915 production showed a conspicuous decrease from that of the previous year.

Gypsum sold in 1915 was classified as follows: lump 342,467 tons; crushed 48,735 tons; fine-ground 6455 tons; and calcined 72,678 tons.

In 1914 the tonnages of the various grades were: lump 351,729 tons; crushed 49,441 tons; fine-ground 6097 tons; and calcined 109,613 tons.

Exports of crude gypsum were 292,234 tons valued at $336,380 being the smallest reported since 1908. Exports of ground gypsum which were valued at less than $10,000 yearly for many years rose to a value of $35,490 in 1914 and to a value of $80,933 in 1915.[1]

Gypsum in the United States

New York (By D. H. Newland).—This State has a leading place in the gypsum industry, both with regard to the mine product and the manufacture of gypsum plasters. Its position in the calcined plaster trade is even more important than the output of rock would indicate, since large quantities of crude gypsum are imported by the local mills for calcination. Most of this foreign material comes from the Maritime Provinces of Canada, under favorable freight rates in normal times, and is used by the tidewater plants in New York City and along the lower Hudson. Nova Scotia is the principal source of supply. Some manufacturers mix the local gypsum with this foreign rock, which is a little whiter in color; the gypsum from Monroe, Genesee and Erie Counties, however, yields a good white stucco, suitable for wall plasters.

There have been no new developments in the mining industry for the last 2 or 3 years, and the output has remained practically stationary. The market for building materials of all kinds has been very quiet. This has effected the trade not only in calcined plasters, but also that in crude gypsum for use in Portland-cement mills. It is satisfactory to note that the industry has fairly held its own in the face of unsatisfactory market conditions.

PRODUCTION OF GYPSUM IN NEW YORK[2]

	1914, Short Tons.	Value.	1915, Short Tons.	Value.
Total output, crude	513,094	....	516,002	....
Sold crude	169,257	$246,804	162,686	$241,511
Ground for land plaster	7,096	15,342	6,536	13,486
Wall plaster, etc., made	297,084	985,268	292,344	1,006,203
Total	....	$1,247,404	....	$1,261,200

The production of gypsum for 1914 and 1915 is shown in the accompanying table, which also gives the several forms in which the output was sold by the mining companies. Considerably more than one-half of the output is converted into calcined plasters by the latter. A few thousand tons are ground for land plaster, and the remainder is sold crude to

[1] Preliminary Report Mineral Production of Canada, 1915.
[2] Authority N. Y. Geol. Surv.

Portland-cement works or to calcining mills outside of the district. There is some fluctuation from year to year in the relative proportions of mined product and the amount of calcined plasters, as the mining companies often hold considerable amounts of rock in stock. The production of calcined plasters from foreign rock is not included in the statistics.

Oklahoma (By L. O. Snider).—For convenience of discussion the gypsum deposits in Oklahoma may be considered as occurring in three areas: (1) The Main Line of Gypsum Hills, along Cimarron River, in the northwestern portion of the State; (2) The Second Line of Gypsum Hills, in the west-central portion; (3) The Southwestern Area.

Main Line of Gypsum Hills.—The main line of Gypsum Hills is produced by the outcrop of the Blaine formation which consists of three beds of gypsum separated by red shales. Of the three beds the lowest one is known as the Ferguson, the middle as the Medicine Lodge and the uppermost as the Shimer.

The line of hills may be regarded as entering Oklahoma from Kansas along the south side of Salt Fork of Arkansas River; then crossing that stream near the Kansas line and extending southwest along the south side, gradually falling back from the river until the hills and the gypsums die out in Canadian County. The extreme southeastern extension of the hills lies nearer the North Canadian River than the Cimarron but the escarpment faces the latter stream.

Near the Kansas line, in Woods, Harper, and Woodward Counties, the three gypsum beds are present but the shales between them are thin and the outcrop often gives the impression that there are only one or two beds. All three gypsums are entirely selenitic, the individual crystals averaging about 2 in. in dimension. This coarsely crystalline texture renders the beds porous and easily penetrated by water. Consequently the effects of solution are very marked. The thickness of the Blaine formation is this vicinity is between 50 and 75 ft. of which half or more is of gypsum.

To the southeast in Major County, the gypsums change in character becoming finer grained from northwest to southeast, so that by the time the Major-Blaine county line is reached the selenitic phase is almost entirely replaced by dense rock gypsum. With this change the effects of solution become less prominent and the outcrops of the three beds are much more distinct and regular.

The outcrop continues to the south and east across Blaine County with little change in the stratigraphy. The gypsums thin somewhat and the intervening clays are a little thicker. The Medicine Lodge gypsum contains considerable anhydrite. Near the eastern boundary of Blaine

County the gypsums thin and become lenticular, finally dying out in northern Canadian County north of El Reno.

Gypsite deposits are common along the first line of gypsum hills but most of those so far known are very small. The only ones developed as yet are in Blaine County, north of Watonga. These beds in the aggregate cover more than 100 acres with the gypsite averaging 6 to 8 ft. thick. The material has been utilized by mills at Watonga, Bickford and Okeene.

Second Line of Gypsum Hills.—Although generally spoken of as a line of hills the gypsum outcrops of this region do not form a single prominent escarpment, as does the outcrop of the Blaine formation just described, but rather a series or body of low, rounded knolls and ridges. The gypsums are present in the lower part of the Green formation. The rocks of the formation are principally soft clay shales, with some soft sandstones and lenticular masses of gypsum. Some of the lenses of gypsum are of considerable extent and thickness, but there are no well-defined beds which can be traced for many miles as can the beds in the Blaine formation. The gypsum varies from fine-grained rock gypsum to coarsely selenitic gypsum and from white to red and green in color.

The area considered as the second line of gypsum hills includes parts of the following counties: Dewey, Ellis, Roger Mills, Custer, Washita, Caddo, Comanche, Grady and Stephens.

In the northern part of the area in Dewey County, and in the small portions of Ellis and Roger Mills which contain gypsum the beds are, for the most part, thin and lenticular. While the total amount of gypsum present is very great there is probably very little which can be considered as available under present conditions of transportation and markets. The only locality observed in these counties where conditions seem at all favorable for development is at Camargo where a bed about 4 ft. thick outcrops along the Wichita Falls and Northwestern Branch of the Missouri, Kansas and Texas Railway.

The important deposits in this area are in the Eastern portions of Custer and Washita Counties. Beginning at Weatherford in southeastern Custer County, and extending southward along Washita River in Washita County is an area containing thick beds of gypsum. Near Weatherford the outcrops of beds of up to 50 ft. in thickness and with very little stripping can be reached.

In Eastern Washita County the gypsums occur in two horizons but the beds in both horizons are more or less lenticular. In many localities, however, beds of 40 to 60 ft. in thickness may be traced for 1 or 2 miles. The gypsum is mostly massive rock gypsum, but selenitic gypsum is not uncommon. The lowest beds are hard and partly anhydritic. Several localities in this area can be reached by spurs from the St. Louis and San Francisco Railroad at a distance of 2 to 4 miles. In the westward extension of the gypsum area in the southern part of the county three distinct ledges occur. These vary in thickness between 15 and 20 ft. The upper and lower ledges are of massive rock gypsum, and the middle one is anhydritic.

The deposits in Caddo, Comanche and Grady Counties are the southeastern extension of those in Washita County just described. The beds become thinner and more lenticular to the southeast so that there are very few if any localities in these counties where the deposits of rock gypsum are of commercial importance.

Important deposits of gypsite are known at Indianapolis in Custer County, at Cement in Caddo County, and at Rush Springs in Grady County. The bed at Indianapolis covers between 60 and 90 acres and has a maximum thickness of 18 ft. The bed has not been developed. The beds at Cement originally covered about 40 acres and had a maximum thickness of about 12 ft. The gypsite from these beds was used in a plaster mill at Cement, which burned in 1911. The greater part of the deposits have been used and there is probably not enough material remaining to justify rebuilding the mill. The deposits at Rush Springs cover more than 50 acres and have an average thickness of about 8 ft. The material is utilized for plaster at a large plant near Rush Springs.

Southwestern Area.—The southwestern gypsum area lies in the extreme southwestern portion of the State in Beckham, Greer, Jackson, and Harmon Counties. The area is probably the southwestward continuation of the second lines of gypsum hills; and the gypsums seem to be at the same horizon as those to the east, that is in the Greer formation. However, the gypsums form well-defined, continuous ledges, especially in the northern part of the area. The outcrop is a steep escarpment rising above a plain of red shales, and is much more similar to the outcrop of the Blaine gypsums, the first line of gypsum hills, than to the eastern portion of the outcrop of the Greer formation, the second line of hills. It is probable that the transition from the eastern portion of the Greer outcrop with the lenticular gypsums forming low, rounded knobs, to the western portion with its well-defined gypsum beds forming a steep escarpment, takes place in the belt along the south side of Washita County where there are three beds which are continuous for a considerable distance.

In southeastern Beckham, in northern Greer County, and the northernmost township of Harmon County there are five distinct gypsum beds. From the base up, these are the Chaney, Kiser, Haystack, Cedartop and Collingsworth.

The Chaney gypsum in the western part of Greer County is a hard, massive layer 3 to 5 ft. thick, usually white but locally gray or blue, and in places is distinctly cross-bedded. To the east the bed thins and finally becomes only a gypsiferous band in the red shale. The Kiser gypsum is variable in character and thickness. Locally it is selenitic, while in other places it is quite shaly. The color is generally drab or bluish. The thickness varies from 1 to 3 ft. The Haystack gypsum is massive, white to gray, and varies from 18 to 25 ft. in thickness. Thin bands of gypsiferous sandstone occur locally. The bed is cut by joints which cause it to weather into rectangular blocks which may cover the slopes for considerable distances below the outcrop of the bed. The Cedartop gypsum is a massive white gypsum, 18 to 20 ft. thick and very similar to the Haystack. The Collingsworth gypsum is of practically the same thickness as the Cedartop and very similar to it and to the Haystack gypsum. It is often absent from the section on account of erosion.

These gypsums outcrop conspicuously on the north side of North Fork of Red River in southeastern Beckham County; cross the river and swing across the divides between North Fork and Elm Fork and form a deep canyon in which Elm Fork flows from the Texas line for about 13 miles to the eastward.

Farther south the gypsum ledges lose their identity and the southern portion of the area more nearly resembles the second line of gypsum hills. In southern Greer County the only outcrops of importance are immediately across Salt Fork of Red River from Mamgum. The greater part of Harmon County is very level and exposures of gypsum are too rare to give an idea as to the extent or thickness of the beds. Their presence is shown, however, by sink holes and in wells.

In western Jackson County the gypsums are more prominent than in southern Harmon County but much less so than along North and Elm forks of Red River. The stratigraphy is very irregular. The best exposures are on Horse Branch and Boggy Creek.

No deposits of gypsite are known in Beckham County. In Harmon County, only two small beds, 3 to 6 ft. thick and with a combined area of about 25 acres are known. In Greer County, about 4 miles west of Willow a station on the Wichita Falls and Northwestern Branch of the Missouri, Kansas and Texas Railway, is a bed covering about 300 acres with a thickness ranging from 4 to 14 ft. This material seems to be an original deposit of very gypsiferous shale and fine sand, rather than true gypsite. It is reported to have been tested and to have made good plaster.

The gypsite beds of Jackson County are among the most important in the State. They are of large extent and are well situated in regard to transportation. The largest bed known in the county covers about

400 acres, just north of the town of Eldorado. The thickness of the gypsite varies from 8 to 20 ft. with little or no stripping. The Eldorado plant of the United States Gypsum Co. is situated at the bed and is reached by a spur from the St. Louis and San Francisco Railroad. The company owns this bed and also controls another bed in the same township. This bed covers about 140 acres and is 6 to 12 ft. thick. The railroad passes near the east end of the bed. Several smaller beds with an aggregate area of 100 acres or more and with thicknesses of 4 to 8 ft. are known in the same portion of the county.

A gypsite bed of approximately 376 acres lies 1 mile east of Duke on the Wichita Falls and Northwestern Branch of the Missouri, Kansas and Texas Railway. The gypsite is 6 to 8 ft. in thickness and has up to 2 ft. cover. Over considerable areas the gypsite lies at the surface. The gypsite is light gray near the surface but grades into pink and reddish-brown in the lower parts of the bed.

Economic Development.—The development of the gypsum industry in Oklahoma has been greatly retarded by poor transportation facilities, the high price of fuel and the remoteness of important markets.

While the resources of gypsum are inexhaustible, in only a comparatively few places are the deposits near enough to railroad lines to render them immediately avaliable. However, sufficient quantities of gypsum are near enough to railroads to sustain an immense production for many years and the lack of transportation is only a minor feature in retarding the growth of the industry.

None of the natural fuels occur in the gypsum area, and coal must be shipped in from the coal fields of Eastern Oklahoma or from Colorado and New Mexico. The fuel expense is necessarily high and makes the cost of the gypsum products much more than in regions more fortunately situated in respect to fuel supply.

By far the most important hindrance to the development of the industry is the distance to the important building centers. None of the cities in the immediate vicinity of the deposits are large enough to provide markets for a large production. The freight rates to the cities of the eastern and central states are prohibitive and, in most cases, the demand for gypsum products can be supplied from deposits much nearer than those in Oklahoma.

The great amount of building in Oklahoma following its admission as a State in 1907 furnished an important local market for plaster. Several mills were built to supply this demand. Since the failure of this market some of the mills have been idle, and others have made only small and intermittent production. Few if any have run to full capacity in the last few years.

At present (1915) there are nine mills operating or in condition to operate in Oklahoma; two at Watonga, and one each at Bickford, Darrow, Southard, Okeene, Alva, Eldorado, and Rush Springs.

The mill at Eldorado is the southwestern gypsum area, the one at Rush Springs at the southeastern end of the second line of gypsum hills and the others along the first line of gypsum hills. Five of the nine mills are in Blaine County. All the mills use the kettle process, except the one near Darrow, which uses the Cumner rotary kiln or continuous process.

The mill of the American Cement Plaster Co. at Watonga is located on the Chicago, Rock Island and Pacific Railroad. The capacity of the mill is about 200 tons of plaster per 24 hr. The rock gypsum is obtained from a quarry in the Medicine Lodge gypsum 7 miles northeast of the plant. The gypsum bed is 12 to 15 ft. thick and there is practically no anhydrite. The rock is crushed at the quarry and the gravel run into railroad cars in which it is conveyed to the mill. Gypsite is secured from a large bed a fraction of a mile distance from the rock quarry. The bed covers about 80 acres, with a maximum thickness of 8 ft. Not over a half of the deposit has been used. The principal products of the mill are the various grades of wall plaster. A considerable portion of the output is used at the mill in the manufacture of partition blocks.

The plant of the Monarch Plaster Co. is also located at Watonga. It is equipped with the ordinary power plant, and crushing and grinding machinery, and two 10-ft. kettles. The quarry is northeast of the plant, only a few rods from that of the American Cement Plaster Co., and gypsite was secured from the eastern portion of the bed utilized by that company. This mill has made only a small production in the last few years.

The mill and quarry of the Roman Nose Gypsum Co. are located at Bickford, about 8 miles north of Watonga on the Chicago, Rock Island and Pacific Railway. The mill is at the foot of the escarpment of the Blaine gypsums and only a short haul by wagon is necessary to transport the rock to the mill. The Medicine Lodge gypsum is quarried. The entire bed is about 15 ft. thick but the middle portion, about 3 ft. is anhydritic. Only the 6-ft. layer above the anhydrite has been used but the lower portion can be obtained easily by stripping the anhydrites. The mill has three 8-ft. kettles for calcining. Power is furnished by a gas producer and gas engine. Partition blocks and wall plasters are the principal products.

The Southwest Cement Plaster Co. has a mill with two 10-ft. kettles at Okeene on the St. Louis and San Francisco Railroad. The rock gypsum is crushed at the quarry, 7 miles south and 2 miles west of Okeene and the gravel hauled to the mill in railroad cars. The portion of the

Medicine Lodge gypsum above the anhydrite member is quarried. Gypsite is secured from a bed near the quarry.

The mill of the Oklahoma Gypsum Co. located west of Darrow on the St. Louis and San Francisco Railroad, is the only one in Oklahoma using the continuous calciner. The quarry is in the Ferguson gypsum which is 6 ft. thick and very pure. The portion of the Medicine Lodge gypsum above the anhydrite is also available and is 10 ft. thick with little stripping. The rock is hauled to the mill in steel dump cars on an elevated tramway.

The mill of the Oklahoma Plaster Co. is at Alva on the Chicago, Rock Island and Pacific and the Atchison, Topeka and Santa Fe Railways. The equipment consists of two 10-ft. kettles with the corresponding crushing and grinding machinery. The quarry is at Belva, in Woodward County, on the Atchison, Topeka and Santa Fe Railway. The Ferguson gypsum, which in this locality is 25 ft. thick and coarsely selenitic, is quarried.

The Southard plant of the United States Gypsum Co. is located at Southard on the St. Louis and San Francisco Railroad. Three 10-ft. kettles are used for calcining. Both the Shimer gypsum and the Medicine Lodge above the anhydrite have been quarried. The Shimer gypsum averages 17 ft. thick in the quarries and is of exceptional purity. The stripping is generally less than 2 ft. The rock is hauled about ¼ mile to the mill in wagons.

The Eldorado plant of the same company is located at Eldorado in Jackson County on the St. Louis and San Francisco Railroad. The mill has four 10-ft. kettles. Gypsite alone is used as the raw material. This is secured from a 400-acre bed immediately north of the mill.

The mill of the Acme Cement Plaster Co. is located west of Rush Springs in Grady County. Gypsite is used as the raw material. The mill is a modern fireproof concrete structure, but no information as to the equipment or capacity is available.

In addition to the plants described others have been operated in the past. Plants at Cement and Marlow have been burned. These were succeeded by the plant at Rush Springs. The United States Gypsum Co.'s mill at Okarche was abandoned in 1912 on account of the exhaustion of the gypsite beds and the difficulty of securing a sufficient supply of rock gypsums. A small mill was operated at Peckham in Kay County several years ago but was removed when the small gypsite beds, from which the raw material was obtained, were exhausted. A two-kettle mill which still stands 4 miles west of Ferguson in Blaine County made a small production but has been idle for many years. On account of its distance from the railroad there is no probability of its resuming operations.

Geologic Relationships.—The gypsums of Oklahoma form a part of the great series of rocks which are generally known as the Redbeds. The greater portion of the Redbeds in Oklahoma are of Permian age and all the gypsums occur in rocks of that age.

Texas (By E. T. Dumble).—The deposits of gypsum which are now being exploited commercially in Texas and Oklahoma occur in connection with the beds of clays, sands and limestones of Permian age, which occupy a broad belt of country lying east of the Staked Plains in Texas, and extending northward from the Texas and Pacific Railway across Oklahoma and Kansas.

As described by Cummins in the Second Annual Report of the Geological Survey of Texas, "in Texas it reaches from the northern line of the State to the line of the Texas and Pacific Railway on the south, and is from 20 to 50 miles wide. The beds are of varying thickness, from that of a knife blade to 20 ft. The east line of the deposit begins on Red River near the mouth of the North Fork and extends to Sweetwater . . . The western boundary is at or near the foot of the Staked Plains."

To the west of the Staked Plains, the erosion of the Pecos River has exposed the continuation of the beds which outcrop east of the Plains and we find another broad area of gypsum deposits lying east of the Guadalupe Mountains and extending northward into New Mexico.

The gypsum, for the most part, occurs massive and in beds of greater or less thickness, extending over very considerable areas, so that the aggregate amount of rock available is vast beyond computation.

In connection with these massive beds, there occur other unconsolidated deposits of the same material, which are of an earthy or sandy nature, and frequently mixed with more or less foreign matter. This is known as gypsite, and it is this form of gypsum which, because of the ease with which it can be worked and its slower setting qualities, is most sought for at the present time, although a certain amount of rock gypsum is also quarried.

Alabaster and other forms of gypsum also occur in connection with these deposits, but so far little or no commercial use has been made of them.

The beginning of the gypsum industry in Texas, was the organization of the Lone Star Plaster Co. at Quanah in May, 1891, for the purpose of mining gypsum and manufacturing land and wall plaster from the gypsite deposits lying west of Quanah. A 75-ton mill was erected at Acme and operations were begun in 1892. Three other mills were erected later at the same locality and the output of these four mills represents practically the entire Texas contribution to the gypsum production of the United States, which has grown from 1420 tons in 1892, to 180,000 tons in 1911, with a value at the mill of about half a million dollars.

The principal factors of cost in the production, and those which will in large measure determine the possibility of extension of the industry, are fuel and transportation.

The fuel question is now met in part, in Texas at least, by the extension of the productive oil fields along the entire length of the belt in which the gypsum deposits are found. Several railroads cross the belt, and transportation should, therefore, be available and ample opportunity be afforded for the erection of mills at places other than those now occupied.

The occurrence of the gypsum deposits of the Permian of North Texas and Oklahoma has been described more or less fully by Cummins, Gould and others, and reference is made to their publications for further details regarding them.

In addition to these deposits, there are others in different parts of Texas which are of equal, if not greater, extent and value, and it may be of interest to call attention to them in this connection.

Mention has already been made of the gypsum deposits lying between the Gaudalupe Mountains and the western scarp of the staked Plains in the valley of the Pecos River.

Richardson says of this:[1]

"The Castile gypsum outcrops in a belt between the Delaware Mountains and Rustler Hills, the width of which averages about 15 miles. though at the New Mexico-Texas boundary it is about 30 miles. This gypsum belt begins about 15 miles north of the railroad and extends into New Mexico. Within Texas the gypsum outcrops over 600 sq. miles The name of the formation is derived from Castile Spring which is in in the midst of the gypsum about 12 miles south of the State boundary.

"The Castile gypsum is a massive white granular variety. It is comparatively pure, and a characteristic sample analyzed qualitatively by Mr. W. T. Schaller shows it to be of no unusual composition. Considering its great extent the Castile gypsum is remarkably homogeneous, yet it varies somewhat. On the surface generally it is disintegrated and earthy. In places it is grayish or dark in color owing to the presence of organic matter and at other places it is stained red by iron oxide. Locally, selenite is abundant. Some sections show occasional thin beds of banded gray limestones in the gypsum. Deposits of native sulphur are also associated with the Castile gypsum. The thickness of this formation is not known, but it is considerable. A well at the old

[1] *Bull. Univ. Tex. Min. Surv.*, No. 9, p. 43.

sulphur works about 6 miles north of Rustler Springs shows a thickness there of a little over 300 ft., though the base of the gypsum is not known to have been reached. Good sections exposing sometimes 50 or 60 ft. of gypsum are shown along Delaware Creek and Cottonwood Draw. Such sections commonly show the rock to be considerably cracked and jointed. This gypsum is also cavernous, and there are many underground channels in it. A conspicuous one heads in a small draw about 6 miles southeast of Sayles' ranch. The opening of the cavern is circular, has a diameter of about 5 ft. and has been explored for a distance of about 1300 ft. This gypsum supports a peculiar variety of bunch grass (*Bouteloua breviseta*) called 'yeso' grass, and also bears a stunted growth of junipers whose occurrence practically is limited to the gypsum."

A number of wells have been drilled for oil in this gypsum area and in some of them the thickness of the gypsum beds penetrated by the drill is greatly in excess of the 300 ft. mentioned by Richardson. Attention may also be called to the occurrence of commercial quantities of sulphur and oil in connection with these gypsum deposits.

Taff has described briefly a large deposit of gypsum which occurs in the Malone Mountains. The mountains lie just south of the Southern Pacific line between El Paso and Sierra Blanca. The main gypsum field, which is included in the Malone beds of the Cretaceous, extends from the center of the mountain to the northeast end, a distance of 5 miles or more.

The basal member of the Malone beds is a band of pale yellow flaggy limestone some 25 ft. in thickness, which is overlain by 45 ft. of gypsum. The outcrop of this is white friable granular material (gypsite). This is followed by 120 ft. of dark blue granular limestone minutely cleaved, metamorphosed and filled with calcite veins, above which is the second gypsum horizon with a thickness of 110 ft. This bed is the same lithologically as the lower one and is a stratified nearly pure granular gypsum, with comparatively little earth matter, a very good grade of gypsite. At one point on the east side of the southeast end of the mountain there is an exposure of the gypsite (probably of the lower horizon) which has a surface area of about 50 acres.

The value of this deposit for commercial purposes is somewhat lessened by its distance from fuel supply and lack of water.

Another, and in some ways a rather remarkable, occurrence of gypsum is found in the southern coastal region of Texas in the neighborhood of Falfurrias.

The area is occupied surficially for the most part by deposits of Pleistocene age, consisting of loose sands and calcareous sandstone which overlie the Reynosa limestone and the Lagarto clays of the Pliocene.

The following description is from notes by Wm. Kennedy: About 6 miles east of Falfurrias, at the southern terminus of the San Antonio and Arkansas Pass Railroad, there is a mound known by the name of Loma Blanca. The mound lies on the south side of a lake formed by the junction and widening out of the Palo Blanco, San Antonio, and a number of other creeks. This lake, which is known as the Laguna de la Loma Blanca, is probably 3 miles long, with a width, where the road crosses, of about a mile, and a depth of not more than 1 or 2 ft. at most, although it is claimed in the rainy season it is somewhat deeper. Laguna de la Loma Blanca appears to have no outlet to the sea except in seasons of excessively wet weather. During dry seasons the water is lost in the sand along the eastern, or seaward extension. Loma Blanca itself covers an area of probably 50 acres and has an elevation of approximately 75 to 100 ft. above the level of the lake. Its northern side rises somewhat abruptly from near the water's edge and and is covered with a soft gypseous sand, containing numerous blocks or bowlders of selenite. This sand thins out toward the crest of the mound, and near the summit on the southern side the deposit of clear transparent selenite is seen to cover an area of several acres. The surface of this bare spot is rain pitted to a depth of 6 or 8 in., and near the middle of this clear space there is a cave or shaft about 36 ft. deep.

The selenite found exposed in the cleared portion of the Loma Blanca lies in layers from 2 to 6 in. in thickness and is perfectly transparent. Blocks free from rain pitting can readily be obtained through which ordinary printed letters can be easily read.

While selenite occurs abundantly in connection with the various gypsum beds of north and west Texas, we have no knowledge of its occurrence anywhere else in a body of such magnitude as in the Loma Blanca.

Gypseous sand (gypsite), containing masses of selenite of the same character of material as that on the Loma Blanca, also forms a south-facing bluff of 25 to 30 ft. in height, extending for several miles along the northern margin of the lake, and it is probable that it forms the bottom of the lake as well. How far this gypsum sand extends back into the country is not known, as it passes under a bed of siliceous sand at a short distance from the edge of the bluff.

The thickness of the deposit is unknown, but it is over 1000 ft. Recently the Producers Oil Co. drilled four wells to depths exceeding this and found practically the same material in each one throughout the whole depth. The deposit, however, appears, from the drilling records, to be more or less cavernous, as in two of the wells the drill passed through a cavity over 20 ft. in depth in each well, which were approximately 500 ft. apart. This cavern lies about 600 ft. below the surface. Smaller cavities were found at various depths.

About 6 miles south and a little west, there is another mound of the same general form and height, known as Alto Colorado, which is also said to be composed of the same kind of gypsum, but no direct connection of the beds has yet been traced between it and the Loma Blanca.

There is a strong probability that this extensive deposit of gypsum is closely related to the mounds occurring in the coastal plain of Louisiana and Texas in connection with the deposits of salt, sulphur and petroleum, since large bodies of gypsum have been encountered in them in drilling.

About 50 miles to the south of the Loma Blanca there are large deposits of salt in two lakes, known as the Sal Vieja and Sal del Rey. These two lakes have been, almost ever since the settlement of the country, the source of the supply of salt, not only for this portion of Texas, but for a large portion of northern Mexico as well. Sal Vieja, although covering a much larger area than Sal del Rey, is not considered as of much importance, as the brine is not quite so concentrated as at the other lake. Sal del Rey is described as a lake in the form of an ellipse about a mile in length. The depth nowhere exceeds 3 or 4 ft. and its bed consists of pure rock salt.

The country between this salt deposit at Sal del Rey and the gypsum deposit at Loma Blanca forms a very extended plain, sloping almost imperceptibly toward the south and east. The surface of this plain is covered with a grayish, and in places brownish-gray sand. The general monotony of this "Llano Grande" is broken by numerous medanos and small lakes, full of brackish water during the rainy season and dry throughout the somewhat prolonged season of dry weather, or during the summer months.

The sand as already mentioned, is somewhat variable in thickness, but thickens from west to east and at the same time from north toward the south. Along the base of Loma Blanca it is only a few feet and west toward Falfurrias this sand does not exceed 8 or 10 ft., where it overlies the Reynosa limestone. Coming southward, the sand shows a thickness of 104 ft. in the well at La Atraveseda and at Loma Prieta, 16 miles farther south, there are only 62 ft. of sand overlying the blue clay. At Gigante, 12 miles west of Loma Prieta, the record of the well shows a surface of reddish colored clay 196 ft. deep. To the east and southeast the sand thickens at El Sanz to 250 ft.

This, together with well records of the underlying blue gypseous clay of the Lagarto indicate a dip to the south and west from the Loma

Blanca, as contrasted with the general southeast dip of all similar formations in other portions of the Texas coastal plain.

Regarding the commercial probabilities of the gypsum deposits in this portion of the State, they may be considered as good. At present they lie about 6 miles from the terminus of the San Antonio and Aransas Pass Railroad, and 14 miles from Sarita on the St. Louis, Brownsville and Mexico Railroad. There are no particular difficulties involving the construction of a branch of either line to the mound.

As regards the mining of the gypsum, very little difficulties need intervene. An open face of at least 60 ft. may be obtained on any side of the hill considered most desirable.

The overlying gypseous sand is sufficiently pure to be used as a fertilizer and much of it might be used in the manufacture of cement plaster and other structural materials. The main body of the selenite is pure enough to be used for any purpose for which gypsum may be required.

New Mills in United States

The Hanover Gypsum Co. with offices at Lewiston, Mont., and plant at Hanover, Mont., began construction of a mill which should be in operation by the summer of 1916.

The United States Gypsum Co., using part of the proceeds from a recent sale of preferred stock, is reported to have started the construction of a mill on the Terence McDonald ranch on Spring Creek, 9 miles below Lewiston and on ground adjoining that of the Hanover Gypsum Co. The gypsum is said to be 6 ft. thick and of good quality. The mill is expected to be producing by July, 1916.

Technology

Committee C-11 of the American Society for Testing Materials has been organized and is at work on the standardization of gypsum and gypsum products. The full report of this committee will probably be submitted to the society in June, 1917.

The Joint Building Code Committee of the Builders Exchange, Cleveland, has proposed that all calcined plasters shall have by weight not more than 5 per cent. upon a 100-mesh sieve "Tyler Standard." They have also proposed a reasonable standard for the sand that is to be used with plasters, and recommend that all calcined plasters show a tensile strength for the neat plaster of 140 lb. in 24 hr. and 250 lb. at the end of 7 days.

The Gypsum Industries Association (By S. G. Webb).—This association has continued its work of developing information regarding physical facts about gypsum and gypsum commodities which are essential in connection with the use of such gypsum commodities in construction. These physical facts include resistance to fire and water of gypsum commodities or constructions now used for various purposes such as partitions, elevator and stairway shaft enclosures, steel protection, floors, roofs, etc. In addition to the questions of fire and water resistance, investigations are continually being conducted into heat and sound conductivity, crushing and impact values and the best methods of use, including developed types of construction for many specific purposes.

The Association has been giving considerable time and attention to the development of standard specifications covering the quality and use of calcined gypsum in wall plasters and in the manufacture of structural forms of gypsum.

The Association has enlarged its field of action and its cope of work and influence and now has a membership including practically all of the producers of calcined gypsum and many of the manufacturers of gypsum commodities located in the United States and Canada. Its permanent headquarters are at 18 East 41st St., New York City and it secured in 1915 incorporation as a membership corporation under the laws of the State of New York.

Australia (By Rowland Lowe).—We have just shipped to Messrs. Noyes Bros., Ltd., of Sydney, Australia, a little complete gypsum plaster plant. It will be, so far as we know, the first gypsum plaster plant used in Australia. Naturally the owners were more conversant with and felt more inclined to the European method, but finally decided to install a small unit of the American type.

The plant consists of a rotary crusher, two initial buhr mills, one 8-ft. kettle, one vibrating screen, one re-grinding buhr mill, one mixer, and a hair picker, together with the usual elevators, conveyors and transmission machinery complete. The plant will be driven by three electric motors totalling 85 hp.

We understand the mill will be erected in or near Sydney, though we don't know the exact location of their quarry.

IRON AND STEEL

By James Aston

"The year 1915 will be remembered in the history of the iron trade of this country by the extraordinary changes which took place during its course and by the remarkable contrast between its opening and closing. These changes were due in part to the condition prevailing in Europe resulting in a tremendous growth of export trade; but in large part also to a growth in domestic business and the active development of home consumption under the influence of increasing business confidence and the abundance of money due to extraordinary crops and the betterment of the banking system under the new law.

"The year 1914 closed with some anticipation of better business, but with no immediate sign of any great improvement over the depressed conditions which then prevailed. Production of pig iron was at the rate of only about 22,000,000 tons a year, a low point as compared with previous years, although it would have been considered high only a few years ago. For the first half of the year this rate increased gradually but slowly and the official report showed little gain over 1914. From July on, however, production of all kinds of finished materials began to increase, and month by month this increase was greater in proportion, until the year closed with an output of pig iron at the rate of 38,000,000 tons a year, the highest ever reached in our industrial history and with a production of finished steel which can not be far from the same tonnage.

"The first impetus to the trade was given by the placing of large orders, mainly for finished steel in various forms, for export to Europe. The countries engaged in war turned to the United States for assistance in supplying munitions and found our manufacturers ready to respond. This class of business grew to large proportions as the year went on, but it was soon found that the foreign demand was being supplemented by a heavy call from domestic consumers. Under the joint influence of the foreign and domestic demand the year closed with our mills and furnaces working closely up to their full capacity and carrying a volume of contracts which seemed to assure them full work during at least the first half of 1916. Many of them, indeed, are indisposed to accept business for the second half, fearing that they will be unable to carry out their contracts. The domestic business comes from all branches of the trade. The railroads, which had been backward for over a year, are increasing their calls for rails and other material. New building construction is already on a large scale and promises to be much greater in the new year, while shipbuilding is demanding more material than ever before. On the whole, it may be said that few years have opened with such prospects for activity as the one which has just begun. Toward the close of the year deliveries of material were delayed by railroad congestion, and exports by lack of ocean steamers."[1]

Several consolidations of independent steel works were talked of during the year. For the most part these have not reached the stage of

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

completion at the close of 1915. The Midvale Steel and Ordnance Co. has taken over the Midvale Steel Co. and the Worth Bros. Co.

In June a decision was reached by the United States Circuit Court of Appeals in favor of the United States Steel Corporation, in the dissolution suit proceedings instituted by the Federal Government.

Iron Ore

The United States Geological Survey reports a total of 55,526,490 gross tons of iron ore mined in the United States in 1915. This is the greatest output of any year except 1910 and 1913. Shipments of ore in 1915 were 55,493,110 gross tons, or but slightly less than the quantity mined. The amount mined in 1915 was an increase of 14,000,000 tons or 40 per cent. over the output of 1914. The average value per ton was $1.83 in 1915 and $1.81 in 1914.

Iron ore was mined in 27 States in 1914 and 23 in 1915. Three of the States—Idaho, Nevada and Utah—produced small quantities for metallurgical flux only; part of the production of California and Colorado was for smelter flux and part for pig iron and ferro-alloys; the remaining States produced iron for blast-furnace use except small tonnages for paint. Minnesota, Michigan, Alabama, Wisconsin and New York, again occupied their accustomed places as the big producers.

The Lake Superior district mined 85 per cent. of the ore in 1915, and the Birmingham district about 8.5 per cent. None of the other districts mined as much as 1,000,000 tons, although the Adirondack and Chattanooga districts showed large increases in output.

Production by States in 1914 and 1915, in long tons, is as follows:

IRON ORE MINED IN THE UNITED STATES IN 1914 AND 1915, GROSS TONS

State.	1914.	1915.
Minnesota	21,946,901	33,464,660
Michigan	10,796,200	12,514,516
Alabama	4,838,959	5,309,354
Wisconsin	886,512	1,095,388
New York	785,377	998,845
Wyoming	366,962	434,513
New Jersey	350,135	415,234
Pennsylvania	406,326	363,309
Virginia	378,520	348,042
Tennessee	330,214	284,185
Georgia	67,722	115,701
North Carolina	57,667	66,453
Missouri	37,554	40,290
New Mexico	81,980	34,806
Colorado	10,464	*
Connecticut	9,149	*
Maryland	6,369	5,500
Nevada	*	3,993
Massachusetts	7,600	3,950
Ohio	5,138	3,455
California	1,282	646
Kentucky	21,400	......
West Virginia	6,530	......
Other States†	40,800	23,650
	41,439,761	55,526,490

* Less than three producers in Colorado and Connecticut in 1915 and in Nevada in 1914, and permission was not granted to publish State totals.

† 1914: Idaho, Mississippi, Montana, Nevada, and Utah; 1915: Colorado, Connecticut, Idaho and Utah.

Production by districts is noted below:

IRON ORE MINED IN THE UNITED STATES, BY MINING DISTRICTS IN 1914 AND 1915

District.	1914.	1915.	Percentage of Change in 1915.
Lake Superior*	33,540,403	46,944,254	+40
Birmingham	4,282,556	4,748,929	+11
Chattanooga	432,006	539,024	+25
Adirondack	544,724	699,213	+28
Northern New Jersey and southeastern New York	541,084	644,493	+19
Other districts	2,098,988	1,950,577	− 7
	41,439,761	55,526,490	+34

* Includes only those mines in Wisconsin which are in the true Lake Superior district.

Stocks of iron ores at mines are estimated to have decreased from 14,361,625 gross tons at the close of 1914 to about 13,000,000 tons at the close of 1915. During the early part of 1915, the demand for iron ore was light. A slight improvement was recorded by the middle of the year, but in the latter part of the summer the trade became very active and the season closed with record shipments for the last few months of the season.

Lake Superior District.[1]—Iron ore shipment from the Lake Superior district in 1915 aggregated 47,272,751 tons. Of this total, 46,318,804 tons were moved by lake, all rail shipments contributing 953,947 tons. The 1915 shipments showed a gain of 14,543,025 tons over 1914, when 32,729,726 tons were forwarded. This increase was 44.43 per cent. of the total movement during 1914.

Production and shipments of iron ore from the Lake Superior district are noted in the following tables:

PRODUCTION OF IRON ORE IN LAKE SUPERIOR DISTRICT
(In tons of 2240 lb.)

Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.	Year.	Tonnage.
1855...	1,449	1880..	1,948,334	1902..	27,562,566	1907..	42,266,668	1912..	46,483,798
1860...	114,401	1885..	2,466,642	1903..	24,289,674	1908..	26,014,987	1913..	52,518,158
1865...	193,758	1890..	9,003,725	1904..	21,822,839	1909..	42,586,869	1914..	33,629,613
1870...	859,507	1895..	10,429,037	1905..	34,353,456	1910..	43,442,397	1915..	46,994,254
1875...	881,166	1900..	19,059,393	1906..	38,522,239	1911..	32,793,120	....	....

SHIPMENTS OF IRON ORE FROM LAKE SUPERIOR DISTRICTS
(In tons of 2240 lb.)

Range.	1910.	1911.	1912.	1913.	1914.	1915.
Marquette	4,392,726	2,833,116	4,202,308	3,966,680	2,491,857	4,105,378
Menominee	4,237,738	2,911,174	4,711,440	4,965,604	3,221,258	4,982,626
Gogebic	4,315,314	2,603,318	4,996,498	4,531,558	3,568,482	5,477,767
Vermillion	1,203,177	1,088,930	1,844,981	1,566,600	1,016,993	1,733,595
Mesabi	29,201,760	22,093,532	32,047,409	34,038,643	21,465,967	29,756,689
Baraboo	91,682	115,629	104,031	145,010	105,765	80,583
Cuyuna	....	147,431	305,111	733,021	859,404	1,136,113
Total	43,442,397	31,793,130	48,211,778	49,947,116	32,729,726	47,272,751

[1] R. V. Sawhill, *Iron Tr. Rev.*, Mar. 16, 1916.

The 1915 shipments have been exceeded in two other years only, 1912 with 48,221,546 tons, and 1913, the record year, with 49,947,116 tons.

Shipments from the Mesabi range in 1915 were 29,756,689 tons, against 21,465,967 tons in 1914, a gain of 8,290,722 tons. Its percentage of the total shipments was 62.95, against 65.62 in 1914; 68.15 in 1913; 66.46 in 1912; and 67.37 in 1911. The Gogebic range again ranked as the second largest shipper, forwarding 5,477,767 tons, against 3,568,482 tons in 1914, a gain of 1,909,285 tons. Its percentage in 1915 was 11.59, against 10.90 in 1914. The 1915 tonnage was the largest since this range was opened, and surpasses by 471,501 tons the previous record made in 1912.

With the exception of 1906, when 5,109,088 tons were forwarded from the Menominee range, 1915 shipments were the largest on record, slightly exceeding 1912 and 1907. The 1915 shipments from the Marquette range have been surpassed in five other years. The Cuyuna range in 1915 forwarded more than 1,000,000 tons for the first time, the gain being 276,709 tons, a percentage increase slightly under that of the district as a whole.

Proportional shipments by ranges are as follows:

	1911.	1912.	1913.	1914.	1915.
Mesabi	67.37	66.46	68.15	65.62	62.95
Gogebic	7.94	10.38	9.07	10.90	11.59
Menominee	11.93	9.77	9.94	9.83	10.54
Marquette	8.64	8.71	7.94	7.61	8.68
Vermillion	3.32	3.83	3.14	3.10	3.67
Cuyuna	0.45	0.63	1.47	2.62	2.40

The ore was forwarded as indicated below:

SHIPMENTS BY PORTS AND ALL-RAIL
(Gross tons)

	1911.	1912.	1913.	1914.	1915.
Escanaba	4,278,445	5,234,655	5,399,444	3,664,451	5,649,289
Marquette	2,200,380	3,296,761	3,137,617	1,755,726	3,099,589
Ashland	2,429,290	4,797,101	4,338,230	3,363,419	5,146,772
Two Harbors	6,367,537	9,370,969	10,075,718	5,610,262	8,642,942
Superior	9,920,490	14,240,714	13,788,343	11,309,748	8,342,793
Duluth	6,934,269	10,495,577	12,331,126	6,318,291	15,437,419
Total by lake	32,130,411	47,435,777	49,070,478	32,021,897	46,318,804
Total by rail	662,719	785,769	876,638	707,829	953,947
Total	32,793,130	48,221,546	49,947,116	32,729,726	47,272,751

Seven mines in the Lake Superior district shipped more than 1,000,000 tons in 1915, as contrasted with four in 1914, eleven in 1913, eleven in 1912, and six in 1911. The Mahoning mine was the leading shipper last year, forwarding 2,311,940 tons, and slightly exceeding the Hull-Rust shipments of 2,294,405 tons.

Leading shippers of the different ranges in 1915 and 1914 are noted below. Leonard, the big producer of 1914 was one of the Steel Corporation mines operated under the "Hill lease," and was the scene of exceptional activity during the last year of the contract. Hull-Rust has been the leading shipper in 6 of the last 9 years.

	1914.	1915.
Mesabi: Mahoning	1,212,287	2,311,940
Hull-Rust	458,468	2,994,405
Canisteo	1,051,895	1,622,182
Sauntry-Alpena	1,131,255	1,455,825
Morris	365	1,167,421
Burt	213,433	1,043,607
Leonard	2,687,285	197,599
Gogebic: Norrie group	984,242	1,408,516
Marquette: Cleveland Cliffs	673,160	634,837
Menominee: Caspian	279,379	479,084
Chapin	340,722	384,654
Vermillion: Zenith	424,110	714,852
Cuyuna: Aurora No. 2	283,565	303,280
Mayville-Baraboo: Mayville	103,549	80,583

There were 209 mines which shipped in 1915, compared with 223 in 1913; 194 in 1912; 184 in 1911; and 196 in 1910. By ranges, the distribution was: Mesabi, 97 in 1915 and 94 in 1914; Menominee, 40 and 41; Marquette, 28 and 25; Gogebic, 26 and 21; Cuyuna 10 and 7; Vermillion, 7 and 6; Mayville-Baraboo 1 and 2.

The following new mines shipped in 1914: Mesabi: Chester, Midway, Philbin, Sullivan and Weed, of the Oliver Iron Mining Co.; Dean, Eddy, Itasca and North Eddy, of the Tod-Stambaugh Co.; Thorne and Wentworth of the Arthur Iron Mining Co.; and North Harrison of Butler Bros.; total 12. Menominee: Balkan, of Pickands, Mather & Co.; Bates, of the Bates Iron Co.; Cottrell, of the Oliver Iron Mining Co.; and Howes of the Wickurie Steel Co.; total 4. Gogebic: North Newport and South Chicago, of the Oliver Iron Mining Co.; total 2. Marquette: Holmes, of the Cleveland-Cliffs Iron Co.; and Iron Mountain Lake of Jones and Laughlin Ore Co.; total 2. Cuyuna: Iron Mountain of the Iron Mountain Mining Co.; total 2.

These 22 shippers in 1915 compare with 16 new mines opened in 1914; 20 in 1913; 13 in 1912; 12 in 1911; and 16 in 1910. Shipments for new mines totaled 1,203,213 tons in 1915, compared with 677,182 tons in 1914; 831,567 tons in 1913; 361,904 tons in 1912; 1,769,423 tons in 1911; and 1,734,044 tons in 1910. Several mines which had been idle for years forwarded ore in 1915. On the contrary, 29 mines which forwarded a total of 1,157,746 tons in 1914, failed to make shipments in 1915. The distribution was: Mesabi, 15; Menominee, 9; Marquette, 2; Gogebic, 1; Cuyuna, 1; Mayville-Baraboo, 1. They were chiefly small producers except the Mississippi mine on the Mesabi range, which shipped 507,660 tons in 1914.

The following table shows the average shipments of all the mines on the six leading ranges and of the whole Lake Superior district for 1915 and 1914:

AVERAGE MINE SHIPMENTS

	1914.	1915.
Mesabi	228,361	306,769
Vermillion	169,499	247,656
Gogebic	169,928	210,683
Marquette	99,674	146,621
Menominee	78,567	124,566
Cuyuna	122,772	113,611
Lake Superior district	166,988	226,186

The independent ore mining companies shared more largely in the increased shipments for 1915 than the United States Steel Corporation, with 52.37 per cent. of the total; this record being the highest attained since the Steel Corporation was organized. It is the fourth successive year that independent interests have shipped over half of the total tonnage forwarded.[1]

Shipments from the mines formerly operated by the United States Steel Corporation under the "Hill lease," which was surrendered at the close of 1914, showed heavy declines during the year. The Arthur Iron Mining Co., which was formed to take over these properties is, however, rapidly perfecting its plans for shipping increased tonnages from these mines as well as new ones now under development.

The following table shows the shipments and percentage of the Oliver Iron Mining Co., the Steel Corporation's mining organization, for each of the last 9 years:

Year.	Gross Tons.	Percentage.
1907	22,710,898	56.00
1908	14,123,957	56.00
1909	21,397,866	50.36
1910	21,661,143	49.86
1911	17,282,499	52.70
1912	23,845,363	49.46
1913	24,502,244	49.06
1914	16,039,654	49.01
1915	22,518,613	47.63

Under the now famous lease between the Great Northern interests and the Steel Corporation, the aggregate minimum shipments required by the terms of the lease amounted to 27,000,000 tons and the report of operations shows that actual shipments were 26,573,808 tons, including 338,246 tons of ore running under 50 per cent. iron. These figures would indicate that the Corporation failed by 426,192 tons to ship the required minimum for the years 1907 to 1914, inclusive. Deficiencies for other than the year 1907 were more than made up, however, and the 612,730 tons deficit for that year was finally waived in 1912 in connection with

[1] R. V. Sawhill, *Iron Tr. Rev.*, Mar. 16, 1916.

negotiations that resulted in the transfer of properties that had not been opened for mining back to the lessor companies in order that they might proceed with the development prior to the time when the lease would terminate. With this waiver, therefore, shipments by the Steel Corporation were 186,538 tons greater for the period than the contract required. Total shipments for the eight-year period were 26,235,562 tons of iron ore of 58.56 per cent. average iron content, upon which the average net royalty was $1.15 per ton; and 338,246 tons of 49 per cent. iron, with $0.345 royalty.[1]

The various properties taken over from the Steel Corporation were operated throughout the season by the Arthur Mining Co., a subsidiary of the Great Northern ore trustees. Development work by these interests was prosecuted vigorously during 1915. Production was 1,679,728 tons for the period from October, 1914, to Dec. 31, 1915; and shipments were 323,731 tons. It is estimated that the Great Northern properties contain 229,282,144 tons in leased ore-bodies, and 190,896,632 tons of ore not leased.

Estimates of tonnage of ore in the ground, as made by the Minnesota Tax Commission, are as follows:

	May 1, 1914.	May 1, 1915.
Mesabi	1,386,093,626	1,382,644,910
Vermillion	11,373,349	10,209,902
Cuyuna	70,857,865	72,215,605
Total	1,468,324,840	1,465,070,417

Shipments for the year were in excess of new tonnage developed, and the deficiency for 1915 would have been greater but for the fact that the Cuyuna reserves were appreciably increased.

The results obtained from the washing plants which have now been in operation on the western Mesabi for several seasons indicate the ore is easier to concentrate than was originally anticipated, and that recoveries are higher than expected, and with more rapid handling. Five washing plants are in operation on the western Mesabi, and two on the Cuyuna range.[2]

There are now 18 mines on the Cuyuna range, all but five of which are underground operations. The north range ores are to a considerable extent contaminated by undecomposed chert. Fortunately, washing will improve the grade, and make available a larger tonnage of otherwise unmarketable material. Results of recent explorations on the south range are quite in contrast, and are exposing large tonnages of over 60 per cent. iron and under 8 per cent. silica. Simple washing of the north range ores raised an ore of as low as 45 per cent. iron to 53 per cent. and

[1] H. C. Estep, *Iron Tr. Rev.*, Jan. 6, 1916.
[2] *Iron Tr. Rev.*, Jan. 6, 1916.

over. With very few exceptions, these deposits are accompanied by more or less manganiferous material. The south range ores are not manganiferous, and not of a sandy or wash grade.[1]

Prices of iron ore for the ensuing season are fixed at a net advance of 75 cts. over those ruling during the season of 1915. According to the new scale, old range Bessemer is quoted at $4.50; Mesabi Bessemer at $4.20; old range non-Bessemer, $3.75, and Mesabi non-Bessemer, $3.55 per ton, delivered at lower lake ports. The selling prices at the date of the buying movement for the period from 1890 to 1916 are given below, for the several grades of ore. Also, for comparison the pig iron prices at corresponding periods are given:[2]

SELLING PRICE OF IRON ORE AND PRICE OF PIG IRON AT DATE OF BUYING MOVEMENT 1891–1916

Season.	Date Buying Movement.	Season Iron Ore Prices.				Iron Prices—Valley.	
		Old Range Bessemer.	Mesabi Bessemer.	Old Range Non-Bessemer.	Mesabi Non-Bessemer.	Bessemer.	Foundry Iron No. 2.
1891	June 1, 1891	$4.50	No sale	$4.25	No sale	$15.15	$15.00
1892	Jan. 31, 1892	4.50	No sale	3.65	No sale	15.00	13.65
1893	Mar. 15, 1893	3.85	$3.00	3.20	No sale	12.65	12.15
1894	Mar. 1, 1894	2.75	2.35	2.50	No sale	9.65	9.65
1895	April 1, 1895	2.90	2.19	2.25	$1.90	9.40	9.40
1896	May 1, 1896	4.00	3.50	2.70	2.25	12.40	11.15
1897	May 20, 1897	2.60	2.25	2.15	1.90	8.35	8.40
1898	Mar. 20, 1898	2.75	2.25	1.85	1.75	9.55	9.80
1899	Feb. 1, 1899	3.00	2.40	2.15	2.00	10.30	9.75
1900	Dec. 15, 1899	5.50	4.50	4.25	4.00	24.15	22.15
1901	April 15, 1901	4.25	3.25	3.00	2.75	16.15	14.40
1902	Feb. 1, 1902	4.25	3.25	2.25	2.75	15.90	15.90
1903	Mar. 20, 1903	4.50	4.00	3.60	3.20	21.50	21.65
1904	April 15, 1904	3.25	3.00	2.75	2.50	13.35	13.15
1905	Feb. 1, 1905	3.75	3.50	3.20	3.00	15.50	16.00
1906	Dec. 5, 1905	4.25	4.00	3.70	3.50	17.25	17.25
1907	Nov. 5, 1906	5.00	4.75	4.20	4.00	21.50	21.50
1908	June 15, 1908	4.50	4.25	3.70	3.50	16.00	15.00
1909	May 10, 1909	4.50	4.25	3.70	3.50	14.75	14.25
1910	Dec. 24, 1909	5.00	4.75	4.20	4.00	19.00	17.25
1911	Apr. 21, 1911	4.50	4.25	3.70	3.50	15.00	13.75
1912	Mar. 20, 1912	3.75	3.50	3.00	2.85	14.25	13.25
1913	Nov. 19, 1912	4.40	4.15	3.60	3.40	17.25	17.50
1914	May 1, 1914	3.75	3.50	3.00	2.85	14.00	13.25
1915	Apr. 19, 1915	3.75	3.50	3.00	2.85	13.60	12.75
1916	Dec. 7, 1915	4.50	4.20	3.75	3.55	18.50	18.00

The fluctuations of the four grades of Lake Superior ore according to the value of units of iron in the natural state are noted in the table below. For the years preceding 1907, the quantity of Bessemer ores was 55.70 per cent. natural and for non-Bessemer it was 52.80 per cent. except Mesabi non-Bessemer for 1905 and 1906, when the natural content was 53 per cent. For 1907 the natural iron-content for the base was changed to 55 per cent. for Bessemer and 51.50 per cent. for non-Bessemer.

[1] C. Zapffe, *Iron Tr. Rev.*, Dec. 19, 1915.
[2] *Iron Tr. Rev.*, Dec. 16, 1915.

VALUE OF UNIT OF IRON FOR 13 YEARS

Fluctuations of iron ore prices exprcssed in values of units of iron in natural statc.

	Old Range.		Mesabi.	
	Bessemer, Cents.	Non-Bessemer, Cents.	Bessemer, Cents.	Non-Bessemer, Cents.
1903	7.94	6.82	7.05	6.06
1904	5.73	5.21	5.29	4.73
1905	6.61	6.06	6.17	5.66
1906	7.50	7.01	7.05	6.60
1907	9.09	8.16	8.64	7.77
1908	8.18	7.18	7.73	6.80
1909	8.18	7.18	7.73	6.80
1910	9.09	8.16	8.64	7.77
1911	8.18	7.18	7.73	6.80
1912	6.82	5.83	6.36	5.53
1913	8.00	6.99	7.55	6.60
1914	6.82	5.83	6.36	5.53
1915	6.82	5.83	6.27	5.44
1916	8.18	7.28	7.64	6.89

The Interstate Commerce Commission reduced the carrying rates from Mesabi range mines to ports at the head of Lake Superior from an existing rate of 60 cts. per long ton to 55 cts., effective June 15, 1915. No change was made with respect to the Vermillion and Cuyuna ranges. Up to 2 years ago the general rate was 80 cts. per ton; it was then reduced to 60 cts. by the action of the ore-carrying roads, but this new rate did not meet the views of independent shippers, and an application for a 40-ct. rate was made to the Interstate Commerce Commission.

Northeastern District.—According to the United States Geological Survey this district, including New York, New Jersey and Pennsylvania, mined 1,343,706 gross tons of ore in 1915, an increase of 21 per cent. over the 1,085,808 forwarded in 1914. The ore was chiefly magnetite.[1]

Shipments of Port Henry, N. Y., ore in 1915 were 555,855 tons, of which 404,095 tons were made during the last 6 months of the year. This compares with approximately 650,000 tons during 1914. Considerable of the ore shipped in 1915 came from stock piles which were accumulated in the preceding 12 months. At the beginning of 1916, however, the district was mining and delivering ore at the heaviest rate in history, and, in view of the large tonnage booked for the year's delivery, as well as the extensions under way, it appears that all records will be exceeded by a wide margin. Sales were made in December for delivery in 1916 of about 2,000,000 tons of ore at prices ranging from 8¼ to 9 cts. per unit, delivered in eastern Pennsylvania, depending on the destination; and at $4 per ton, at the mines, for lump, or an advance of 75 cts. per ton over the previous year. Practically the full output of the Port Henry mines for 1916 was contracted for.

Witherbee, Sherman and Co., the leading Port Henry operators, are

[1] *Iron Tr. Rev.*, Mar. 16, 1916.

making important developments. A new concentrating mill has been completed, the largest unit of its type in the world, having capacity for treating 1400 tons of crude ore in a 9-hr. run. With the development of new openings, and enlargements and improvements under way, these Port Henry properties will have a total crude ore output in 1916 of approximately 1,500,000 tons, and a yield of concentrates of about 1,250,-000 tons. This will represent an increase of 400 to 500 per cent. in the company's mining operations during the past 10 years.

Considerable stimulus to operation is expected with the completion of the new Champlain barge canal, and docks and other facilities are being provided to take care of the increased tonnage. Inauguration of traffic is expected by Sept. 1, 1916, and the new canal should enable ore to be laid down in eastern Pennsylvania valleys at a transportation cost of $1 per ton, compared with $1.60 per ton at the present time.

Production and shipments of ore from the Cornwall bank in eastern Pennsylvania for the fiscal year ending Mar. 31, 1916, are estimated at 332,385 tons, being the smallest in many years. Of the total, about 250,-000 tons was taken by the Pennsylvania Steel Co. The average annual shipments for the last 11 years has been 524,755 tons, with a maximum in 1907 of 807,118 tons. Facilities are being provided for increased production and for concentrating and sintering greater tonnages

In New Jersey, important enlargements and betterments have been put through by the Empire Iron and Steel Co., materially increasing the output. At present, shipments from the Oxford and Mt. Hope mines are running at about 30,000 tons monthly.

Since 1870, the mines of New Jersey have yielded 20,490,407 tons of ore, inclusive of 1914. In that year five mines in operation produced 350,135 tons; there was marketed, however, 846,820 tons. There has been a gradual diminution in the number of active mines, not because the mines have been worked out, but because under present conditions of competition with Lake Superior and Cuban ores, only a few of the New Jersey deposits are economically available.

Southern District.—The United States Geological Survey reports output of iron ore in the Birmingham and other Alabama districts to have been 4,748,929 gross tons in 1915, an increase of 8.8 per cent. over 1914, when the output was 4,282,556 tons. Other Southeastern States, including Georgia, North Carolina, Tennessee and Virginia, shipped approximately 694,000 gross tons, compared with 619,769 tons in 1914, an increase of 12 per cent.

The United States Geological Survey has made a reconnaissance of the iron-ore deposits of northeastern Texas. Analyses of numerous samples show the following average percentages of metallic iron: Cass

County, 48.64 per cent.; Marion County, 54.91 per cent.; Morris County, 54.83 per cent.; and Cherokee County, 44.64 per cent. As most of the so-called brown ores used in this country carry about 45 per cent. of iron the brown ores of this Texas district are above average grade. The profitable exploitation, however, probably depends on the application of some relatively economical scheme of mechanical concentration.

Colorado.—The Colorado Fuel and Iron Co. produced 441,026 tons of iron ore in the year ended June 30, 1915, as compared with 614,039 tons in the year previous. The properties are in Colorado, New Mexico and Wyoming.

Alaska.—Considerable local interest has been shown in deposits of iron ore in an area that centers about 25 miles northwest of Nome, Alaska. Last year Henry M. Eakin, of the United States Geological Survey, made a hasty examination of some of the more important properties in this locality and his report has just been made public by the Survey in *Bulletin* 622-I.

Five groups of claims are held in the iron-bearing district, but little development work had been done on them at the time of the examination, so that it is not possible to estimate the quantity of ore available.

Those who are interested in the iron ores have proposed the construction of a railroad from the vicinity of the properties to the coast along the Sinuk River valley. The route is apparently practicable and would give a down grade all the way to the coast, a distance of about 14 miles.[1]

Imports.[2]—During the first half of 1915, the poor market for iron and steel products caused a very light demand for iron ore; this, coupled with the liberal stocks carried over from the previous year, limited new purchases, and restricted the market for import ores to the very cheapest. With the growth of furnace activity in the last half of the year, there was demand for foreign ores by Eastern furnaces, but the influence of war conditions on the supply and transportation came sharply into play. The direct outcome was that shipments of foreign ores to the United States were practically the same as in the lean year 1914, which in turn had the lowest record since 1908, when 776,989 tons were brought in. Receipts of trans-Atlantic ores were less than 300,000 tons, or the smallest since 1908. In 1914 they were about 410,000 tons, and in 1913 about 500,000 tons. Foreign ore imports during the last 5 years are as follows:

Freight rates operated to raise a barrier against outside ores requiring carriage over long ocean routes. From the Mediterranean the toll

[1] *U. S. Geol. Surv. Press Bull.*, Oct., 1915.
[2] *Iron Tr. Rev.*, Mar. 16, 1916.

FOREIGN ORE IMPORTS DURING LAST FIVE YEARS

	1911.	1912.	1913.	1914.	1915.
Cuba	1,147,879	1,398,593	1,635,622	815,017	831,618
Sweden	219,238	333,863	356,074	280,887	204,632
Spain	194,965	92,061	112,580	66,982	42,092
Chile	....	....	....	45,000	146,000
Canada	50,480	106,675	179,860	52,514	84,124
Africa	4,443	....	12,950	46,175	22,000
Miscellaneous	184,727	173,584	297,684	44,793	10,815
	1,811,732	2,104,576	2,594,770	1,351,368	1,341,281

Of the tonnage imported in 1915, the port of Philadelphia received 687,780 tons; Baltimore, 572,813 tons; and the balance came in at Cleveland, Chicago and other ports.

quickly rose to 13 s. from a normal rate of 8 s. Much of the foreign ore imported in 1915 from other than North American districts, was on undelivered tonnages engaged in previous years.

Cuban tonnages would have been considerably higher but for scarcity of vessels and consequent high freights. This difficulty prompted the Pennsylvania Steel Co. to build two 12,000-ton ore carriers to offset in large degree the necessity of chartering vessels in the open market. Cuban ores of low phosphorous-content were sold at 10½ to 11 cts. per unit, at tidewater points.

Practically all of the ore imported from Sweden went to the Bethlehem Steel Co. on a long-term contract which has been running for several years. African ore deliveries were light, due to freight and labor difficulties. About 17,000 tons were sold at the relatively low price of 7½ cts. per unit at tidewater, on a favorable freight engagement. There were no imports of Wabana, Newfoundland, ores in 1915, due to more lucrative employment in other trade of the vessels of the operating companies.

Shipments from the Tofo mines in Chile of the Bethlehem Steel Co. were seriously interfered with by the interruption of traffic through the Panama Canal, and the expected tonnage for the season from this source was considerably curtailed.

Exports.—Exports of iron ore from the United States in 1915 were 708,641 gross tons, compared with 551,618 tons in 1914 and 1,042,151 tons in 1913. This exportation is chiefly to Canada.

Iron and Steel Markets

The opening weeks of the year 1915 were marked by a continuation of the depression which prevailed at the close of 1914, although there were a few rays of hope for better things, and steel works were operating at a somewhat higher rate than the 25 to 30 per cent. of capacity which prevailed in the latter months of 1914. A few branches of the trade were active, due to war orders and special reasons; but there was an absence of buying by the railroads, agricultural interests and other important consumers whose requirements set the pace in general steel works activities.[1]

Progress from the depth to the summit was rapid, with perhaps the fastest recovery ever seen in the history of the iron and steel industry.

In December, 1914, pig-iron prices were the lowest since 1904, and finished steel prices the lowest since 1899. The high prices reached in the year found their parallel in the general level attained in 1906 and 1907, but the prices then were reached by a slow and steady movement. In 1912 prices were somewhat higher than prevailed at the close of 1915, but that price level was attained by relatively slow stages. In 1899 prices rose as rapidly as in 1915, and reached a materially high level, but there was the very important difference between 1899 and 1915 that substantially full production occurred for about 2 years preceding. During 1915, on the other hand, the rate of pig-iron production more than doubled and the rate of steel production fully tripled. Pig-iron prices scored an average advance of more than \$5 per ton. Bessemer billets advanced about \$12 per ton, while finished-steel products generally scored an average advance of more than \$12 a ton; and this latter does not take into account the premium prices paid for prompt deliveries toward the close of the year. The advance in pig iron was practically entirely after the first half of the year; while in the case of steel, there was a slight advance, about \$2 a ton, during the first half, followed by rapid rises which became violent in the last quarter. The early support of the steel market was probably largely war demand, but this was offset in a very large part in the latter part of the year by specifications for domestic consumption.

Below are given the average prices at Chicago of pig iron and some standard finished-steel products for several years; the former being listed in dollars per gross ton; the latter in cents per pound:

With respect to pig iron the Chicago market was tardy, and until Aug. 1 the price of iron at Chicago furnaces remained at \$13. In the 4 months following the price rose to \$18, with occasional panicky conditions in the last quarter. Lake Superior charcoal iron advanced strongly and surplus stocks accumulated in lean years were disposed of. Southern iron maintained a price schedule closely paralleling that of the competitive product of northern furnaces.[2]

In the Pittsburgh district, the pig-iron market, like that of other products not directly affected by the war, did not become active until

[1] B. E. V. Luty, *Eng. Min. Jour.*, Jan. 8, 1916.
[2] *Iron Tr. Rev.*, Jan. 6, 1916.

AVERAGE CHICAGO PRICES OF PIG IRON

	Northern Coke No. 2.	Lake Superior Charcoal.	Southern Coke No. 2.	Common Bar Iron, Cents.	Soft Steel Bars, Cents.	Structural Steel, Cents.
January	$13.00	$15.75	$13.50	0.98	1.289	1.289
February	13.00	15.75	13.50	1.05	1.289	1.289
March	12.94	15.75	13.50	1.11	1.302	1.327
April	13.00	15.75	13.50	1.14	1.343	1.343
May	13.00	15.75	13.50	1.15	1.389	1.369
June	13.00	15.75	13.63	1.20	1.389	1.389
July	13.00	15.75	13.75	1.20	1.439	1.429
August	13.44	16.00	14.56	1.23	1.514	1.489
September	13.90	15.85	15.40	1.29	1.539	1.539
October	14.62	15.75	15.88	1.38	1.602	1.577
November	17.13	17.00	17.75	1.50	1.789	1.789
December	18.20	18.65	18.30	1.69	1.929	1.949
Average for year	$14.02	$16.10	$14.73	1.24	1.484	1.482
Average for 1914	$13.60	$15.60	$14.46	$1.06	$1.32	$1.34
Average for 1913	15.95	16.50	16.12	1.43	1.55	1.60
Average for 1912	15.32	16.77	16.11	1.32	1.42	1.46
Average for 1911	14.87	16.96	14.80	1.22	1.47	1.50
Average for 1910	17.10	18.67	16.30	1.45	1.62	1.66
Average for 1909	17.49	19.50	17.30	1.43	1.50	1.59
Average for 1908	17.57	20.24	16.76	1.56	1.66	1.82
Average for 1907	24.50	26.56	24.47	1.78	1.77	1.87

after the close of the first half of 1915. Prices showed no important changes in position the first and second quarters, but there was every indication of an advance as soon as the long-expected buying movement got under way. This began in July, and pig-iron prices responded quickly to the increased demand, and gradually climbed to high levels in the last quarter. All available producing capacity was put into blast; and several furnaces were lighted which had been idle for many years.[1]

Bessemer iron advanced $5.15 a ton during 1915, from a low point of $14.55 in March, April and May, to a high point of $19.70 for December quotations; and sales at $20 or more in the last 2 weeks of the year. Basic iron registered a nominal advance of $5.10 a ton during the year, the low figure of $13.45 prevailing in the first 5 months, and the high figure of $18.55 being the quotations in December. The actual advance was greater than the above because of sales at $19.35, Pittsburgh, in the latter part of the year. Foundry, malleable, and gray forge irons followed the general trend of weakness with tendency to sag in the early months of the year, with subsequent recovery and rise of price at the close; nominal advances were $5.40, $5.40, and $4.95 per ton, respectively. Actual variation of low to high figures were somewhat higher due to sales at higher than market quotations for prompt delivery.

Average monthly prices at Pittsburgh are given in the accompanying table:

The demand for semi-finished steel was light in the first 3 or 4 months of 1915, and there was no improvement in prices over those at the close

[1] *Iron Tr. Rev.*, Jan. 6, 1916.

AVERAGE MONTHLY PRICES AT PITTSBURGH IN 1915

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Bessemer pig iron	$14.70	$14.55	$14.63	$14.55	$14.55	$14.58	$14.88	$15.89	$16.80	$16.95	$17.45	$19.70
Basic pig iron	13.45	13.45	13.45	13.45	13.45	13.54	13.83	14.89	15.65	15.95	16.70	18.55
Foundry pig iron	13.70	13.95	13.80	13.45	13.45	13.45	13.60	14.70	15.45	15.57	16.45	18.85
Malleable pig iron	13.70	13.70	13.80	13.45	13.45	13.45	13.60	14.70	15.45	15.57	16.45	18.85
Gray forge pig iron	13.45	13.45	13.45	13.40	13.20	13.20	13.20	14.20	14.95	15.07	15.88	18.15
Ferro-silicon	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	79.00	83.75	83.00
Bessemer billets	19.50	19.50	19.50	19.50	19.50	19.87	21.40	23.00	24.60	25.50	27.75	29.60
Open-hearth billets	19.50	19.50	19.50	19.50	19.50	19.87	21.50	24.00	25.60	26.50	28.00	30.20
Bessemer sheet bars	20.00	20.00	20.00	19.60	19.50	20.37	21.70	24.00	24.60	25.50	28.25	30.80
Open-hearth sheet bars	20.00	20.00	20.00	19.60	20.00	20.37	22.00	25.00	25.80	26.50	28.50	30.80
Steel rails	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.
Beams	1.10c.	1.10c.	1.15c.	1.15c.	1.20c.	1.20c.	1.25c.	1.30c.	1.34c.	1.41c.	1.625c.	1.74c.
Plates	1.10c.	1.10c.	1.125c.	1.11c.	1.125c.	1.15c.	1.22c.	1.30c.	1.32c.	1.42c.	1.625c.	1.74c.
Steel bars	1.10c.	1.10c.	1.15c.	1.20c.	1.20c.	1.20c.	1.26c.	1.30c.	1.34c.	1.41c.	1.625c.	1.74c.
Iron bars	1.12c.	1.10c.	1.10c.	1.20c.	1.20c.	1.24c.	1.25c.	1.30c.	1.37c.	1.47c.	1.60c.	1.84c.
Tin plate	$3.10	$3.10	$3.10	$3.20	$3.18	$3.10	$3.10	$3.10	$3.10	$3.10	$3.35	$3.60
No. 28 black sheets	1.80c.	1.80c.	1.80c.	1.80c.	1.80c.	1.80c.	1.77c.	1.83c.	1.92c.	2.05c.	2.22c.	2.50c.
No. 28 galvanized sheets	2.77c.	3.01c.	3.40c.	3.30c.	3.40c.	4.46c.	4.55c.	3.93c.	3.67c.	3.50c.	3.90c.	4.75c.
No 10 blue sheets	1.30c.	1.30c.	1.30c.	1.30c.	1.35c.	1.35c.	1.35c.	1.36c.	1.52c.	1.60c.	1.85c.	2.25c.
Wire rods	$25.00	$25.00	$25.00	$25.00	$25.00	$25.00	$25.60	$26.75	$28.50	$30.00	$34.50	$39.00
Wire nails	1.51	1.55	1.60	1.59	1.55	1.55	1.59	1.61	1.69	1.76	1.87	1.98
Plain wire	1.31	1.35	1.40	1.39	1.35	1.35	1.39	1.42	1.54	1.62	1.72	1.83
Hoops	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.25c.	1.26c.	1.32c.	1.42c.	1.52c.	1.75c.	1.94c.
Heavy melting steel	$11.55	$11.62	$12.00	$11.90	$11.75	$11.75	$11.75	$13.38	$14.25	$14.00	$15.31	$17.40
Structural rivets	1.45c.	1.45c.	1.45c.	1.45c.	1.45c.	1.49c.	1.50c.	1.50c.	1.61c.	1.75c.	2.28c.	2.46c.

of 1914. In January, billets, both Bessemer and open-hearth, were to be had at $19, Pittsburgh. In the last 6 months the trade in semi-finished steel was extraordinarily active, and there was almost a famine in billets, with the result that mills in position to make prompt deliveries were able to secure almost any price asked. Billets advanced $11.50 per ton, and sheet bars $13 a ton during the 12-month period. Forging billets were in especial demand, and sold at $55 and over during the last quarter, an advance of $30 per ton during the year. Open-hearth steel products were relatively stronger than Bessemer material until November, when the differential in price disappeared.[1]

The year 1915 was the best that Pittsburgh steel-rail mills have experienced for a long time; partially due to heavy export orders and in part to domestic demand in the last half of the year. Prices of standard section Bessemer rails were held steadily at $1.25 throughout the year; and of open-hearth rails at $1.34 Pittsburgh.[2]

Demand for structural shapes in the first 3 or 4 months was dull, but it began to increase in May, and grew rapidly, so that at the close of the year fabricating concerns are stocked with orders for several months ahead. Beams and channels rose from $1.10, Pittsburgh, to $1.74 quoted at the close of the year. But $2 to $2.25 was being paid for prompt shipment.

The steel-plate market followed the general trend of moderate demand in the early months of the year, and extreme activity at the close of the year, with large mills sold up for months ahead. Prices advanced from $1.05 to $1.10, Pittsburgh, at the beginning of the year, to minimum quotations of $1.74 at the close, with premiums of $2 to $5 per ton for prompt deliveries.

The market for tubular goods opened weak and ended strong, and in the closing months of 1915, both steel and wrought-iron pipe mills were operating at close to capacity. Black steel pipe up to 6 in. in diameter advanced $4 a ton during the year, and parallel advances were made by the iron-pipe manufacturers. Steel boiler tubes advanced $15 a ton in the last 7 months of the year, and seamless tubing commanded the highest prices reached in many years.

There was considerable fluctuation in the price of galvanized products, pipe, sheets and wire, because of the irregularity in the price of spelter. This was listed at 5.45 cts., East St. Louis, on Jan. 1; at 8.75 cts. on Apr. 1; at 22 cts. on July 1; and 17.50 cts. on Dec. 16. Galavanized sheets experienced variations in quotation of $40 per ton during the year, with high prices prevailing at the close. The high cost of zinc had a pro-

[1] *Iron Age*, Jan. 6, 1916.
[2] *Iron Age*, Jan. 6, 1916.

nounced effect in cutting the demand, and at no time during the year were galvanizing works operating at close to capacity. Consumers turned to non-galvanized products to tide over their requirements.

Sheet bars were scarce and deliveries uncertain in the last half of 1915, and in conformity the prices of black and blue annealed sheets, low in the first period, advanced sharply. Black steel sheets advanced $15 a ton, from 1.75 cts. to 2.50 cts. for No. 28 gage; and blue annealed products rose $19 a ton, from 1.30 cts. to 2.25 cts. for No. 10 gage.

The market for wire products experienced a wave of unprecedented prosperity during 1915, and mills are engaged at maximum capacity for several months of 1916. Much of the demand may be attributed to the European war. Wire products in 1915 commanded the highest prices recorded in 7 years. Plain wire advanced from 1.31 cts. to 1.83 cts. during the year.

The price of all commodities entering into the manufacture of tin plate advanced considerably during the year, and there was of necessity a corresponding increase in the price of the product, exclusive of that due to direct supply and demand. Tin-plate quotations for the opening of the 1915 season were $3.20 per 100-lb. base, but there was shading of this figure by all mills. Pig tin and sheet bars at this time were quoted at 33.5 cts. and $19.50 respectively. Tin-plate quotations remained with very little change until the closing months of the year, when prices for the 1916 season were formally announced as $3.60 per 100-lb. cokes, f.o.b. Pittsburgh. At this time pig iron was quoted at 38 cts. to 39 cts., and sheet bars were at an average of $27.50. Market conditions at the close of the year were such that the $3.60 price was well maintained.

Old material followed the trend of the pig-iron market, and the first half was a period of stagnation. Demand became unusually heavy shortly after the opening of the second half, with accompanying jumps in price to almost unprecedented levels. Heavy melting steel advanced from $11.55 to $17.40, with some sales before the end of the year at prices above those of basic pig iron, an unusual circumstance.

Pig Iron

Beginning the year with an average daily production of about 51,000 tons in January, the blast furnaces of the United States were turning out metal at the rate of over 101,000 tons a day in November, a gain of almost 100 per cent. Production in December reached a total of 3,201,605 tons, a new high record. This was a daily output of 103,277 tons, against 48,236 tons in December, 1914. Output for the last half year was at the rate of over 35,000,000 tons per year. The developments of the year are illustrated in the accompanying table of monthly production of blast furnaces, for the past 3 years:

MONTHLY PRODUCTION

	1915.	1914.	1913.
January	1,591,024	1,879,336	2,787,800
February	1,666,592	1,888,607	2,578,670
March	2,046,280	2,341,551	2,762,823
April	2,114,518	2,261,501	2,754,353
May	2,255,157	2,097,019	2,816,825
June	2,369,932	1,904,566	2,616,883
Total first half	12,043,503	12,372,580	16,317,354
July	2,563,311	1,955,324	2,558,275
August	2,774,825	1,996,483	2,537,018
September	2,834,342	1,882,718	2,494,098
October	3,120,340	1,767,227	2,539,924
November	3,035,235	1,501,269	2,229,960
December	3,201,605	1,495,325	1,976,138
Total second half	17,529,658	10,598,346	14,335,413
Grand total	29,573,161	22,970,926	30,652,767

Pig iron output in the United States since 1820 is given in the following table:

PIG-IRON PRODUCTION FOR 100 YEARS

1820	20,000	1859	750,650	1878	2,301,215	1897	9,652,680
1828	130,000	1860	821,223	1879	2,741,853	1898	11,773,934
1829	142,000	1861	653,164	1880	3,835,191	1899	13,620,703
1830	165,000	1862	703,270	1881	4,144,254	1900	13,789,242
1831	191,000	1863	846,075	1882	4,623,323	1901	15,878,354
1832	200,000	1864	1,014,282	1883	4,595,510	1902	17,821,307
1840	286,903	1865	831,770	1884	4,097,868	1903	18,009,252
1842	215,000	1866	1,205,663	1885	4,044,526	1904	16,497,033
1846	765,000	1867	1,305,023	1886	5,683,329	1905	22,992,380
1847	800,000	1868	1,431,250	1887	6,417,148	1906	25,307,191
1848	800,000	1869	1,711,287	1888	6,489,738	1907	25,781,361
1849	650,000	1870	1,665,179	1889	7,603,642	1908	15,936,018
1850	563,755	1871	1,706,793	1890	9,202,703	1909	25,795,471
1852	500,000	1872	2,548,713	1891	8,279,870	1910	27,303,567
1854	657,337	1873	2,560,963	1892	9,157,000	1911	23,649,547
1855	700,159	1874	2,401,262	1893	7,124,502	1912	29,726,937
1856	788,515	1875	2,023,733	1894	6,657,388	1913	30,966,301
1857	712,640	1876	1,868,961	1895	9,446,308	1914	23,332,244
1858	629,548	1877	2,066,594	1896	8,623,127	1915	29,916,213

Below is given the production by half yearly periods for 1910 to 1915, in gross tons as compiled by the American Iron and Steel Institute. All pig iron and ferro-alloys are included, whether made in blast furnaces or in electric furnaces:[1]

Periods.	1910.	1911.	1912.	1913.	1914.	1915.
First half	14,978,738	11,666,996	14,072,274	16,488,602	12,536,094	12,233,791
Second half	12,324,829	11,982,551	15,654,663	14,476,699	10,796,150	17,682,422
Total	27,303,567	23,649,547	29,726,937	30,966,301	23,332,244	29,916,213

Marked increases in production are noted for all States, except Tennessee and Virginia. These increases varied between 27.57 and 32.46

[1] *Bull.* 1, 1916, Amer. Iron & Steel Inst.

per cent. in the important producing States of Indiana, Ohio, Pennsylvania, New York and Illinois. The excessive demand for steel-making irons, as compared with those of foundry grade, is shown in the relatively smaller increases in southern territory—the gain in Alabama was 12.18 per cent. During the year Pennsylvania produced 42.75 per cent. of the country's output, Ohio, 23.11, Illinois, 8.18, New York and New Jersey, 7.04, Alabama, 6.85, and Indiana and Michigan, 6.64 per cent. of the total.

Production by States is as follows:

PRODUCTION OF PIG IRON BY STATES
(In tons of 2240 lb.)

States.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Massachusetts and Connecticut..	18,388	16,582	9,649	17,366	12,810	6,594	7,802
New York.	1,733,675	1,938,407	1,562,756	1,939,231	} 2,187,620	1,559,864	2,104,780
New Jersey.	294,474	264,781	40,663	36,876			
Pennsylvania ...	10,918,824	11,272,323	9,807,073	12,552,131	12,954,940	9,733,369	12,790,668
Maryland........	286,856	326,214	255,816	219,546	289,959	195,594	251,548
Virginia.........	391,134	444,976	293,642	256,167	341,815	271,228	251,346
Alabama........	1,763,617	1,939,147	1,712,211	1,862,681	2,057,911	1,826,929	2,049,453
N. Car., Geo., Texas.	26,072	14,725	1,200	*Nil.*	....	....	....
West Virginia. ..	228,282	174,661	291,472	274,360	} 315,731	(b)236,393	(b)291,040
Kentucky.......	86,371	100,509	95,202	68,760			
Tennessee.......	333,845	397,569	324,648	338,238	280,541	216,738	177,729
Ohio............	5,551,545	5,752,112	5,310,506	6,802,493	7,129,525	5,283,426	6,912,962
Illinois	2,467,155	2,675,646	2,108,002	2,887,359	(a)2,927,977	1,847,451	2,447,220
Michigan........	(a)964,289	(a)1,250,103	1,163,932	(a)1,770,628	1,775,883	(a)1,557,355	a1,986,778
Wisconsin, Minn.	348,177	307,200	276,807	303,370	367,326	329,526	372,966
W. of Miss. River	382,767	428,612	395,968	397,731	324,263	267,777	271,921
Total.........	25,795,471	27,303,567	23,649,547	29,726,937	30,966,301	23,332,244	29,916,213

(*a*) Includes Indiana. (*b*) Includes Mississippi.

Production of pig iron from 1909 to 1915 according to fuel used, is given below:

PIG-IRON PRODUCTION ACCORDING TO THE FUEL USED
(In tons of 2240 lb.)

Fuel Used.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Coke(*a*)..........	24,721,037	26,257,978	23,141,296	29,132,733	30,348,973	22,976,856	29,535,308
Anthracite & coke	682,383	628,579	212,548	236,467	254,901	} 91,464	84,753
Anthracite alone...	16,048	20,503	17,027	10,712	22,446		
Charcoal.......... Charcoal & coke..	} (*b*)376,003	396,507	278,676	347,025	339,981	263,924	296,152
Total..........	25,795,471	27,303,567	23,649,547	29,726,937	30,966,301	23,332,244	29,916,213

(*a*) Under coke furnaces are included the very few which use raw bituminous coal. It may be assumed that 99 per cent. of this class of iron was made with coke. (*b*) Includes a small quantity made by the electric furnace.

Below is listed the production of pig iron according to character of product. Low-phosphorus pig iron, that is, running under 0.04 per cent. phosphorus, is included in Bessemer pig iron; the latter is iron containing from 0.04 to 0.10 per cent. phosphorus. The figures for the last 3 years include under basic iron a small quantity of charcoal iron of basic grade. Nearly all of the charcoal iron is classed as foundry iron; pig iron of high silicon-content is included in the foundry group, which under "all other grades" are included white and mottled iron, direct castings, and miscellaneous ferro-alloys.

PRODUCTION OF PIG IRON BY GRADES, 1906–1915

Years.	Basic.	Bessemer.	Foundry.	Malleable.	Forge.	All Other.	Total, Gross Tons.
1906	5,018,674	13,840,518	4,773,011	699,701	597,420	377,867	25,307,191
1907	5,375,219	13,231,620	5,151,209	920,290	683,167	419,856	25,781,361
1908	4,010,144	7,216,976	3,637,622	414,957	457,164	199,155	15,936,018
1909	8,250,225	10,557,370	5,322,415	658,048	725,624	281,789	25,795,471
1910	9,084,608	11,245,642	5,260,447	843,123	564,157	305,590	27,303,567
1911	8,520,020	9,409,303	4,468,940	612,533	408,841	229,910	23,649,547
1912	11,417,886	11,664,015	5,073,873	825,643	469,183	276,337	29,726,937
1913	12,536,693	11,590,113	5,220,343	993,736	324,407	300,860	30,966,152
1914	9,670,687	7,859,127	4,533,254	671,771	361,651	235,754	23,332,244
1915	13,093,214	10,523,306	4,864,348	829,921	316,214	289,210	29,916,213

During the year there were relative increases in the production of steel-making irons (basic and Bessemer) as compared with foundry grades, emphasizing the demand for steel. Bessemer iron amounted to 80.2 per cent. of basic pig output in 1915, compared with 81.3 per cent. in 1914.

Of the 29,916,213 tons of pig iron made in 1915, 8,583,007 tons, or 28.7 per cent., was for sale. In 1914 the production was 31.5 per cent.; steel-making interests had no surplus in the past year. Of the 1915 total for sale, 4,801,711 tons was of foundry grade, and 829,921 of malleable. Basic iron sold aggregated 1,747,265 tons, and Bessemer 871,730.

The forms in which the pig iron made in recent years was delivered are given below:

METHODS BY WHICH ALL PIG IRON WAS CAST OR DELIVERED

States.	Molten Condition.	Sand Cast.	Machine Cast.	Chill Cast.	Direct Castings.	Total, Gross Tons.
Mass., Conn.	....	7,802	....	....	....	7,802
N. Y., N. J., Md.	983,342	886,330	377,021	109,084	551	2,356,328
Pennsylvania	8,162,376	1,115,761	3,187,069	319,735	5,727	12,790,668
Va., W. Va., Ala.	653,097	1,493,241	231,129	101,617	5,406	2,484,490
Kentucky, Tenn.	....	239,172	37,707	8,199	....	285,078
Ohio	4,000,000	919,493	1,805,619	181,580	6,270	6,912,962
Ind., Ill., Mich., Col.	3,310,076	234,212	1,137,657	....	3,357	4,685,302
Wis., Minn., Mo., Cal.	....	180,458	192,906	20,198	21	393,583
Total	17,108,891	5,076,469	6,969,108	740,413	21,332	29,916,213

The number of blast furnaces in the United States at the close of each year since 1910, is given in the following table:

BLAST FURNACES IN UNITED STATES

Fuel Used—Blast Furnaces.	1910.	1911.	1912.	1913.	1914.	1915.
Bituminous coal and coke....	382	385	395	394	389	390
Anthracite, and anth, and coke	42	35	26	23	20	15
Charcoal....................	50	45	45	45	42	40
Total.....................	474	465	466	462	451	445

Of the 445 blast furnaces in the United States at the close of 1915, 310 were in blast and 135 idle. On June 30, 236 were operating. Detailed figures are given below:

Fuel used—active and idle furnaces.	1914.						1915.					
	First half.			Second half.			First half.			Second half.		
	Active.	Idle.	Total.	Active.	Idle.	Total.	Active.	Idle.	Total.	Active.	Idle.	Total.
Bituminous, chiefly coke.	189	200	389	144	245	389	219	171	390	289	101	390
Anthracite and coke..... } Anthracite alone........ }	5	15	20	3	17	20	2	13	15	4	11	15
Charcoal...............	14	28	42	17	25	42	15	25	40	17	23	40
Total................	208	243	451	164	287	451	236	209	445	310	135	445

Ten new blast furnaces were projected during the year, on which work will be done in 1916, as compared with only three in 1914. The total capacity of the furnaces is 1,750,000 gross tons per year. The furnaces completed during the year included two by the Minnesota Steel Co. at Duluth, Minn., and one by the Pennsylvania Steel Co. at Steelton, Pa. All are rated at 500 tons.

Total capacity of new blast furnaces blown in recent years is as follows:

Year.	Gross Tons.
1905	1,292,000
1906	1,135,000
1907	2,065,000
1908	1,188,000
1909	1,930,000
1910	1,794,000
1911	565,000
1912	1,000,000
1913	550,000
1914	None
1915	530,000

Steel

Steel production for the year amounted to 32,151,035 tons. Steel outputs of the United States for a number of years past are given in the following table:

STEEL PRODUCTION FOR 13 YEARS
(In tons of 2240 lb.)

	Acid.								Basic.		Total.
	Converter.		Open-hearth.		Crucible, etc.		Total.		Open-hearth.		
	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.	P.c.	Tons.
1903	8,592,829	59.1	1,094,998	7.5	112,238	0.8	9,800,065	67.4	4,734,913	32.6	14,534,978
1904	7,859,140	56.7	801,799	5.8	92,581	0.7	8,753,520	63.2	5,106,367	36.8	13,859,887
1905	10,941,375	54.6	1,155,648	5.8	111,196	0.6	12,208,219	61.0	7,815,728	39.0	20,023,947
1906	12,275,830	52.5	1,321,653	5.6	141,893	0.6	13,739,376	58.7	9,658,760	41.3	23,398,136
1907	11,667,549	49.9	1,269,773	5.5	145,309	0.6	13,082,631	56.0	10,279,315	44.0	23,361,946
1908	6,116,755	43.7	696,304	4.9	69,763	0.5	6,882,822	49.4	7,140,425	50.9	14,023,247
1909	9,330,783	39.0	1,076,464	4.5	130,302	0.5	10,537,549	44.0	13,417,472	56.0	23,955,021
1910	9,412,772	36.1	1,212,180	4.6	177,638	0.7	10,802,590	41.4	15,292,329	58.6	26,094,919
1911	7,947,854	33.6	912,718	3.8	129,602	0.4	8,990,174	37.8	14,685,932	62.2	23,676,106
1912	10,327,901	33.4	1,139,221	3.6	142,679	0.4	11,609,801	37.2	19,641,502	62.8	31,251,303
1913	9,545,706	30.5	1,255,305	4.0	155,237	0.5	10,956,248	35.0	20,344,626	65.0	31,300,874
1914	6,220,846	26.5	903,555	3.8	117,500	0.5	7,241,901	30.8	16,271,129	69.2	23,513,030
1915	8,287,213	25.8	1,370,377	4.3	184,721	0.6	9,842,311	30.6	22,308,725	69.4	32,151,036

During the year 29 new open-hearth furnaces were completed, with an annual capacity of 1,405,000 tons of steel. Of these seven, with an estimated output of 280,000 tons, were constructed by the Steel Corporation at Duluth; the others are owned by independent companies. At the close of the year there were under construction 91 open-hearth furnaces of a total annual capacity of 4,265,000 tons. Of these, 18 with an output of 1,550,000 tons, are being built by subsidiaries of the United States Steel Corporation, and 73, with an estimated tonnage of 2,715,000 tons, are under construction by independent companies. The combined capacity of open-hearth furnaces completed or building during 1915 will add about 5,700,000 tons to the annual steel producing capacity of the United States.[1]

There was a very great expansion of the electric steel-making industry in the United States in 1915. The capacity, either built or under construction at the close of the year is estimated at 450,000 tons annually, an increase in the year of about 100 per cent. The United States now leads all other countries, having surpassed Germany. On completion of present construction there will be 40 Heroult, 12 Snyder, 4 Girod, 3 induction type, and 14 of other types in this country, a total of 73, compared with 41 a year previous. On Jan. 1, 1916, Germany had 53 electric furnaces, and a year before, 46.

The larger proportion of the electric furnaces will produce alloy and special carbon steel, and steel for small castings. The crucible process is being discarded in a number of plants in favor of the electric furnace. Tonnage manufacture of electric steel in the United States is increasing annually, amounting to 69,412 tons in 1915, as compared with 24,009 tons in 1914.

[1] *Iron Age*, Jan. 6, 1916.

The following table gives the annual output of the important iron and steel forms, for recent years:

	1911.	1912.	1913.	1914.	1915.
Rails	2,822,790	3,327,915	3,502,780	1,945,095	2,204,203
Plates and sheets	4,488,049	5,875,080	5,751,037	4,719,246	6,077,694
Wire rods	2,450,453	2,653,553	2,464,807	2,431,817	3,095,907
Structural shapes	1,912,367	2,846,487	3,004,972	2,031,124	2,437,003
Nail plate	48,522	45,331	37,503	38,573	31,929
Bars, skelp, and all other forms	7,316,990	9,908,475	10,030,144	7,204,444	10,546,188
	19,039,171	24,656,841	24,791,243	18,370,196	24.392,924

Rails

The total production of steel rails in the United States in 1915 was 2,204,203 gross tons, against 1,945,095 tons in 1914, an increase of 13.3 per cent. Compared with other steel forms, this was a relatively small gain; in fact in 1915 the production of rails constituted a smaller proportion of the pig-iron output than in any other year on record. Below is given the record of rail production for the period 1906 to 1915, according to process of manufacture:[1]

PRODUCTION OF ALL KINDS OF RAILS

Years, Rails.	Open-hearth Steel.	Bessemer Steel.	Re-rolled Steel.*	Electric Steel.	Iron.	Total.
1906	186,413	3,791,459	....	....	15	3,977,887
1907	252,704	3,380,025	....	....	925	3,633,654
1908	571,791	1,349,153	....	....	71	1,921,015
1909	1,256,674	1,767,171	....	†	....	3,023,845
1910	1,751,359	1,884,442	....	†	230	3,636,031
1911	1,676,923	1,053,420	91,751	462	234	2,822,790
1912	2,105,144	1,099,926	119,390	3,455	....	3,327,915
1913	2,527,710	817,591	155,043	2,436	....	3,502,780
1914	1,525,851	323,897	95,169	178	....	1,945,095
1915	1,775,168	326,952	102,083	....	....	2,204,203

* Re-rolled from old steel rails and renewed rails which the manufacturers could not classify as Bessemer or open-hearth. Included with Bessemer and open-hearth steel rails to 1910. † Small tonnages rolled in 1909 and 1910 but not included with Bessemer and open-hearth rails for these years.

Open-hearth rails continued their progress in supplanting Bessemer, their proportion of the total being 80.4 per cent. in 1915, compared with 78.45 per cent. in 1914, and 72.16 per cent. in 1913.

No rails were made by the electric process in 1915, and the product reached its maximum output of 3455 tons in 1912.

Included in the table above are girder and high T-rails for electric and street railways; the tonnages were: 1915, 133,965; 1914, 136,889; 1913, 195,659; 1912, 174,004 tons.

[1] *Bull.* 2, 1916, Amer. Iron & Steel Inst.

Of the total 1915 production, 694,545 tons, or 31.5 per cent. were rolled in Pennsylvania mills, against 30.5 per cent. in 1914.

During the year 22 rail mills were active, of which 14 made open-hearth, and 9 made Bessemer, and 9 made re-rolled rails.

Production according to weight of section is given below for recent years:

WEIGHT OF ALL KINDS OF RAILS FROM 1906 TO 1915

Years—Gross Tons.	Under 45 Lb. per Yard.	45 Lb. and Less than 85.	85 Lb. and Over per Yard.	Total Gross Tons.
1906	284,612	1,749,650	1,943,625	3,977,887
1907	295,838	1,569,985	1,767,831	3,633,654
1908	183,869	687,632	1,049,514	1,921,015
1909	255,726	1,024,856	1,743,263	3,023,845
1910	260,709	1,275,339	2,099,983	3,636,031
1911	218,758	1,067,696	1,536,336	2,822,790
1912	248,672	1,118,592	1,960,651	3,327,915
1913	*270,405	†967,313	2,265,062	3,502,780
1914	*238,423	†309,865	1,396,807	1,945,095
1915	254,102	518,291	1,431,811	2,204,203

* Include rails under 50 lb. † Include 50 lb. and less than 85 lb.

Included in the totals of rail production are alloy-treated rails; detailed figures for this class of product are noted below. In spite of increased rail output, there was a further decline in the use of titanium additions, and the tonnage so treated in 1915, is the lowest since statistics were first collected in 1909.

	Total Production.	Titanium.	Other Alloys.
1909	49,395	35,945	13,450
1910	257,324	256,759	565
1911	153,989	152,990	999
1912	149,267	141,773	7,494
1913	59,519	47,655	11,864
1914	27,937	23,321	4,616
1915	24,970	21,191	3,779

U. S. Steel Corporation.—The gross receipts of the Corporation for 1915, $726,683,589, were the third largest in its history, these figures being passed only in 1912 and 1907. Gross receipts in 1915 were $168,268,656 over 1914, a gain of 30 per cent. Net earnings increased $58,732,396 or nearly 82 per cent. Shipments to customers of all classes of products except cement were 10,982,748 tons, an increase of 1,272,347 tons over 1914. Prices received in 1915 averaged 26 cts. a ton more than 1914 on domestic business, and $4.19 per ton more on export business.

Industrial operations of the Corporation for several years are noted in the accompanying table:

[1] *Iron Age*, Mar. 23, 1916.

PRODUCTION OF THE U. S. STEEL CORPORATION
Including Tennessee C., I., & Ry. Company

	1910.	1911.	1912.	1913.	1914.	1915.
Iron Ore Mined—	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
From Marquette Range	830,094	560,685	551,575	583,266	496,896	618,108
From Menominee Range	1,386,465	1,105,044	995,401	980,346	874,909	939,304
From Gogebic Range	1,801,480	1,264,734	1,497,950	1,871,700	1,469,601	1,277,419
From Vermilion Range	1,338,110	1,182,075	1,301,663	1,301,163	1,112,854	1,273,825
From Mesabi Range	17,910,366	14,581,530	20,001,953	21,634,206	10,894,463	17,209,664
In Southern Region	1,981,301	1,239,563	2,079,907	2,367,770	2,186,258	2,351,356
Total	25,247,816	19,933,631	26,428,449	28,738,451	17,034,981	23,669,676
Coke Manufactured	13,649,578	12,120,212	16,719,387	16,663,480	11,163,914	14,500,818
Coal Mined, not used in making coke	4,850,111	5,290,671	5,905,153	6,705,381	5,271,911	5,828,278
Limestone Quarried	5,005,087	4,835,703	6,124,541	6,338,509	4,676,479	5,795,925
Blast Furnace Products—						
Pig iron	11,645,510	10,593,726	13,990,329	13,879,706	9,909,062	13,517,598
Spiegel	102,260	66,435	53,829	65,236	25,397	7,175
Ferromanganese and Silicon	83,628	84,736	142,006	135,788	117,998	116,735
Total	11,831,398	10,744,897	14,186,164	14,080,730	10,052,457	13,641,508
Steel Ingot Production—						
Bessemer ingots	5,796,223	5,055,696	6,643,147	6,131,809	4,151,510	5,584,198
Open-hearth ingots	8,383,146	7,697,674	10,258,076	10,524,552	7,674,966	10,792,294
Total	14,179,369	12,753,370	16,901,223	16,656,361	11,826,476	16,376,492
Rolled and Other Finished Products for Sale—						
Steel rails	2,118,473	1,568,028	1,857,407	1,927,745	979,907	1,129,832
Blooms, Billets, Slabs, Tinplate Bars	682,364	874,474	1,103,752	1,108,147	921,826	1,404,443
Plates	929,020	630,512	1,076,308	....	689,241	974,741
Heavy Structural Shapes	656,797	547,186	898,537	998,624	613,739	726,082
Merchant Steel, Skelp, Hoops, Bands	1.527,506	1,221,606	1,910,512	2,024,192	1,423,740	2,118,366
Tubing and Pipe	868,550	863,670	1,111,138	1,186,740	818,435	919,280
Rods	133,722	118,302	196,720	174,478	164,153	261,036
Wire and Products of Wire	1,490,318	1,613,754	1,629,717	1,432,182	1,380,376	1,771,945
Sheets—Black, Galvanized and Tinplate	1,082,787	1,079,046	1,508,607	1,280,537	1,075,419	1,368,178
Finished Structural Work	589,228	518,399	599,301	652,363	521,225	476,896
Angle and Splice Bars and Joints	235,998	160,855	192,488	256,676	129,849	190,758
Spikes, Bolts, Nuts and Rivets	71,326	60,386	83,426	86,465	62,133	74,289
Axles	101,066	52,046	142,367	159,075	64,662	95,476
Sundry Iron and Steel Products	246,840	167,984	196,339	245,439	117,159	251,317
Total	10,733,995	9,476,248	12,506,619	11,532,663	9,014,512	11,762,639
Spelter	26,777	28,333	31,318	30,424	28,031	32,031
Copperas (Sulphates of Iron)	33,684	28,381	35,215	33,829	30,212	35,377
Universal Portland Cement (Bbl.)	7,001,500	7,737,500	10,114,500	11,197,000	9,116,000	7,648,658

Imports and Exports.—United States imports and exports of iron and steel are tabulated below. Exports were heavy in practically all lines, and reached record figures in those products entering into the manufacture of munitions or utilized for war purposes.

UNITED STATES EXPORTS OF DOMESTIC IRON AND STEEL
(In tons of 2240 lb.)

	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Pig iron	46,696	61,999	127,385	120,799	272,676	277,648	114,423	224,499
Billets, blooms, etc.	112,177	104,862	58,230	234,267	294,818	91,847	50,496	560,728
Bars	46,103	87,960	125,606	141,033	230,139	228,331	128,228	465,720
Rails	196,510	299,540	353,180	420,874	446,473	460,553	174,680	391,491
Sheets and plates	104,993	180,048	274,516	372,373	546,968	463,414	280,090	418,290
Structural steel	116,878	90,830	146,721	223,493	288,164	403,264	182,395	232,937
Wire	136,167	149,341	171,928	229,316	244,711	190,282	180,839	473,579
Wire-rods	7,412	20,142	22,869	22,641	65,470	61,636	61,853	165,010
Nails and spikes	38,906	48,055	61,201	77,833	92,497	62,726	49,622	118,349
Pipe and fittings	114,371	162,140	155,728	197,597	249,856	301,784	199,618	176,884

UNITED STATES IMPORTS OF IRON AND STEEL
(In tons of 2240 lb.)

	1907.	1908.	1909.	1910.	1911.	1913.	1912.	1914.	1915.
Pig iron......	489,440	92,202	174,988	237,233	148,459	129,325	165,450	138,903	89,836
Billets, blooms, etc...	19,334	12,112	19,913	46,578	29,205	18,702	26,675	49,188	14,998
Scrap iron and steel..	27,687	5,090	63,504	72,764	17,272	23,612	44,154	34,849	79,982
Bars................	39,746	19,672	19,206	43,692	26,729	26,112	28,243	16,414	8,520
Rails................	3,752	1,719	1,513	....	....	3,780	10,408	22,571	78,525
Wire-rods...........	17,076	11,208	10,544	20,374	15,483	15,070	16,097	6,954	5,316
Tinplate............	57,773	58,320	62,593	66,640	14,099	2,052	20,680	15,411	2,350

The world's production of iron and steel, so far as data are available for the different countries, is noted in the accompanying tables:

PIG-IRON PRODUCTION OF THE WORLD
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1906.....	1,403,500	1,431,160	550,628	3,319,032	12,478,067	30,450	2,350,000
1907.....	1,405,000	1,427,940	590,444	3,588,949	13,045,760	32,000	2,768,220
1908.....	1,650,000	1,206,440	572,284	3,391,150	11,813,511	112,924	2,748,000
1909.....	1,958,786	1,632,350	686,886	3,632,105	12,917,653	207,800	2,871,332
1910.....	2,010,000	1,852,090	726,471	4,032,459	14,793,325	215,000	3,042,046
1911.....	2,095,000	2,046,280	832,376	4,426,469	15,280,527	302,931	3,521,000
1912.....	2,312,689	2,301,290	920,636	4,871,992	17,852,571	379,987	4,197,638
1913.....	2,369,864	2,484,690	1,024,424	5,311,316	19,291,920	426,775	4,548,376
1914.....	2,020,000	1,560,000	710,481	5,025,000	14,389,547	385,114	4,261,008
1915.....	1,960,000	....	828,920	4,750,000	11,790,199	395,000	3,696,560

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1906..........	387,500	552,250	10,311,778	25,706,882	650,000	59,171,237
1907..........	385,000	603,100	10,082,638	26,193,863	556,900	60,679,814
1908..........	403,500	563,300	9,438,477	16,190,994	550,000	48,640,419
1909..........	389,000	443,000	9,818,916	26,108,199	550,000	61,217,064
1910..........	367,000	604,300	10,380,723	27,636,687	525,000	66,210,720
1911..........	408,667	633,800	9,718,638	24,027,940	535,000	63,210,694
1912..........	403,243	701,900	8,751,464	30,202,568	540,000	73,529,929
1913..........	424,773	735,000	10,481,917	31,482,406	550,500	79,395,472
1914..........	435,000	635,100	9,005,898	23,721,115	495,000	62,844,609
1915..........	419,000	767,600	8,793,659	30,414,816	480,000	64,515,928

STEEL PRODUCTION OF THE WORLD
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Canada.	France.	Germany.	Italy.	Russia.
1905.....	1,188,000	1,023,500	409,927	2,210,284	10,066,553	117,300	2,208,000
1906.....	1,195,000	1,185,660	580,056	2,371,377	11,135,085	109,000	2,431,000
1907.....	1,195,500	1,183,500	641,369	2,677,805	12,063,632	115,000	2,600,000
1908.....	2,025,182	1,065,500	534,631	2,727,717	10,480,349	537,000	2,628,000
1909.....	1,969,538	1,370,000	684,677	3,034,571	12,049,834	661,600	3,071,000
1910.....	2,188,371	1,449,500	745,971	3,506,497	13,698,638	635,000	3,479,000
1911.....	2,363,008	2,192,630	800,504	3,680,613	15,019,333	736,000	3,870,000
1912.....	2.785,105	2,515,040	868,811	4,078,352	17,301,998	801,951	4,498,000
1913.....	2,682,619	....	1,060,503	4,419,241	18,958,819	911,500	4,827,000
1914.....	2,190,759		751,738	....	15,619,719	....	....
1915	2,686,226	....	....	....	13,237,646	....	4,018,000

Year.	Spain.	Sweden.	United Kingdom.	United States.	All Other Countries.	Total.
1905	264,970	340,000	5,812,282	20,354,291	426,000	43,900,648
1906	289,732	351,900	6,462,274	23,772,506	420,000	49,635,998
1907	297,684	443,000	6,522,748	23,733,391	405,000	51,273,340
1908	301,360	427,100	5,295,642	14,247,619	300,000	44,359,522
1909	309,479	310,600	5,881,628	24,338,302	325,000	53,499,974
1910	316,301	468,600	6,374,481	26,512,437	315,000	58,656,312
1911	322,981	456,500	6,461,612	24,054,918	325,000	58,275,701
1912	317,880	508,300	6,796,144	31,751,324	....	....
1913	365,118	582,700	7,663,876	31,822,555	....	....
1914	....	500,600	7,835,113	23,904,914	....	....
1915	....	588,800	8,350,994	32,686,887	....	....

Foreign Countries

Australia.—Interest centered in the opening of the new steel works at New Castle, New South Wales, which have been erected by the Broken Hill Proprietary Co. at a cost of $7,500,000. The plant consists of one blast furnace, three open-hearth furnaces, and a structural and rail mill, together with coke ovens. The present capacity is about 10,000 tons of steel per month. The ore is obtained in South Australia and has an average iron content of 68 per cent.

Austria-Hungary.—Steel output of Austria-Hungary in 1915 is given as 2,686,226 metric tons, compared with 2,190,759 tons in 1914, and 2,684,-619 tons in 1913. Distribution was as follows:

	1915.	1914.	1913.
Bessemer steel	241,690	164,113	275,481
Open-hearth	2,370,947	1,958,725	2,283,819
Puddled-iron and steel	23,543	30,350	58,740
Crucible	26,151	17,557	39,742
Electric	23,895	19,884	26,837
Total	2,686,226	2,190,759	2,684,619

Of this total for 1915, Austria produced 1,987,802 tons; Hungary 688,267 tons, and Bosnia 19,157 tons.

Belgium.—Owing to the disorganization wrought by the war, no statistics are available. Production of pig iron and steel in recent years is given below:

PIG-IRON PRODUCTION IN BELGIUM
(In metric tons)

	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Foundry iron	100,020	76,190	89,960	(*a*) 83,710	(*a*) 60,630	(*a*) 96,620	27,665
Forge iron	226,430	127,630	156,590	115,760	102,690	66,940	92,825
Steel pig	1,101,490	1,002,620	1,386,800	1,652,620	1,882,960	2,137,730	2,356,040
Total	1,427,940	1,206,440	1,632,350	1,852,090	2,046,280	2,301,290	2,476,530

(*a*) Includes special cast irons.

STEEL PRODUCTION IN BELGIUM

	Bessemer.	Open-hearth.	Castings.	Total.
1905	1,095,880	104,550	26,680	1,227,110
1906	1,277,010	118,130	45,720	1,440,860
1907	1,289,750	176,960	54,900	1,521,610
1908	1,070,840	127,160	51,620	1,250,620
1909	1,470,400	109,950	52,040	1,632,390
1910	1,755,500	136,660	52,660	1,944,820
1911	1,971,760	156,410	64,460	2,192,630
1912	2,252,380	190,040	72,620	2,515,040

Belgian steel plants have not been materially impaired physically by the German invasion, but the entire industry has been rather demoralized.

Some of the iron and steel works have been operating during the year. The blast furnaces at LaLouviere and Thiriau, the structural plants at Bouvy, and the rolling mills at Gilson are reported to be working steadily; while the Haine Saint Pierre blast furnaces have been operating on part time, and steel plants in other districts are working on a restricted scale. Most of the steel works closed the year with considerable financial loss.

The iron and steel industry of Belgium is centered in the southern part of the country around Charleroi and Liege, and has existed there for many centuries.[1] Coking coal exists in the district. Iron ore for acid Bessemer working is brought from Spain, and such pig iron constitutes about one-sixth of the total. The main ore supply is from the Minette district just over the Southern frontier, Luxembourg, Longwy, and Briey. These ores are of high phosphorus-content, producing a pig iron adapted to basic Bessemer working. The iron-content is relatively low, but is materially raised by calcination; again the limey character of the ore makes it self-fluxing and offsets the seemingly low grade. As in Germany and France, the basic Bessemer process is used preferentially for steel manufacture, although the open-hearth furnace has some place in the industry.

Brazil (By Benjamin L. Miller and Joseph T. Singewald, Jr.).—During 1915 there was little activity in the iron industry of Brazil. From 1910 to 1914 several foreign companies—American, English, and German—had parties in the field investigating and buying the best of the high-grade iron ore lands in Minas Geraes. These have now largely passed into the hands of foreigners although some excellent properties are still retained by Brazilian families.

When the Brazilian people witnessed the competition in the acquisition of the iron-ore lands their hopes were raised to expect that mining might soon be started but there seems to be no immediate prospect of such a realization. It has become apparent to all concerned that it is

[1] H. H. Campbell, *Iron Age*, May 25, 1916.

improbable that much iron or steel will soon be made in Brazil, on account of the absence of coking coal, while the present railroad facilities will scarcely permit ore to be economically transported to ports for shipment to foreign countries. The Central Railroad, which passes through part of the iron region, is not adapted for hauling ore and the railroad that is being built from the port of Victoria is not much better. Until a suitable railroad is built the companies holding the ore lands will undoubtedly remain inactive although Minas Geraes contains the most extensive deposits of high-grade iron ore known.

A small amount of pig iron is made from the loose flakes of specular hematite ore, called jacutinga, in several places. The ore mixed with charcoal is melted in a small furnace and the slag pounded out by means of a trip-hammer run by a waterwheel. One small blast furnace was also operated during 1915.

Notwithstanding the possession of several billions of tons of high-grade iron ore Brazil is dependent upon other countries for almost its entire supply of iron and steel, amounting to about 500,000 tons annually.

Canada.—Iron-ore shipments of Canada in 1915, amounted to 398,112 short tons, as compared with 1914 shipments of 244,854 short tons. Mine operators reported 93,444 tons of ore exported to the United States and 304,668 tons shipped to Canadian furnaces.

Exports of iron ore amounted to 79,770 tons, and imports to 1,499,722 tons, according to records of the Customs Department. Imports include shipments from Newfoundland.

Shipments from the Wabana Mines, Newfoundland, in 1915, were 868,451 short tons, of which 802,128 tons were shipped to Cape Breton, and 66,323 tons went to England. In 1914 the shipments were 639,430 short tons, of which 422,920 tons went to Cape Breton and 216,510 to the United States and Europe.

Total production of pig iron in Canadian blast furnaces in 1915 was 913,719 short tons, as compared with 783,164 short tons in 1914. Of the 1915 total, 13,692 tons were made with charcoal and 900,027 tons with coke.

The blast-furnace plants operated included those of the Dominion Iron and Steel Co.; the Nova Scotia Steel and Iron Co. at Sydney, N. S.; the Standard Iron Co. at Deseronto, Ont.; the Steel Co. of Canada, at Hamilton, Ont.; the Canadian Furnace Co. at Port Colborne, Ont., and the Algoma Steel Co. at Sault Ste. Marie, Ont.

There was also in 1915 a production in electric furnaces of 10,794 tons ferro-alloys (chiefly ferro-silicon).

Exports of pig iron in 1915 were 17,307 net tons, and of ferro-alloys

[1] Mineral Prod. of Canada, 1915.

9238 tons; the total in 1914 was 19,063 tons. Imports of pig iron were 47,482 tons in 1915; spiegeleisen, ferro-manganese, and ferro-silicon imports amounted to 61,240 tons.

Steel-production statistics for 1915 are not available. There was a material increase in production, however, over the 694,447 tons reported in 1914.

The Dominion Iron and Steel Co.'s output of various products in 1915 was approximately as follows: pig iron 309,800 tons; steel ingots, 349,000 tons; blooms, billets, and slabs for sale, 119,999 tons; rails, 57,500 tons; wire rods, 73,500 tons; merchant bars, 78,000 tons; wire and wire products, 34,000 tons.

New openhearth and electric furnaces are being installed by the Steel Co. of Canada, The Canadian Steel Foundries, and the Canada Cement Co.

Chile (By Benjamin L. Miller and Joseph T. Singewald, Jr.).—During 1915 the Bethlehem-Chile Iron Mines Co. continued to operate and develop its iron ore deposits at Tofo. The ore is still taken from Tofo to the harbor at Cruz Grande by means of an aerial tram. From the ore pile a traveling belt takes the ore out on a cantilever from which it is run into the hold of the vessels. This method of transportation of the ore is unsatisfactory because of the limited capacity of the tram line and by the close of 1916 it is hoped to have the railroad in operation. Most of the grading for it was completed during 1915.

The method of loading the vessels now in use has proved objectionable, as the scant protection in the small harbor prevents vessels lying beneath the cantilever, except when the ocean is comparatively calm, and, at times, vessels might be compelled to lie offshore for several days awaiting favorable conditions for loading. To remedy this situation a basin is being constructed by excavating in the solid rock. It is hoped to have the basin completed by the time the railroad is ready for operation.

Construction work was continued throughout the year both at Cruz Grande and at Tofo, many new houses, shops, loading pockets, etc., being built and much new equipment imported.

The water problem has become serious on account of the small amount of rainfall. The supply which has been obtained from an old copper mine at La Higuera, a few miles away, will probably prove to be insufficient and plans are being formulated for the evaporation of sea water.

During the year the investigation of the ore-body was continued by driving tunnels into the hill at lower levels. The information obtained furnished the basis for estimating the deposit to contain approximately 100,000,000 tons of high-grade ore most of which is of Bessemer grade.

Except for a few small dikes that cut through the ore-body, the entire top of the Tofo hill is solid iron ore of commercial grade workable by steam shovels.

The geologic study of the ore and associated rocks lead to the belief that it has originated by magnetic differentiation from basic igneous rocks of which anorthosite, gabbro, and diabase are the most common. Near the ore-body the rocks have undergone marked alteration to serpentines while much epidote is also present. Within the solid ore there are numerous golden-colored fragments of altered amphiboles. The contact between the ore and the rock is fairly sharp although some isolated blocks of altered rock are to be observed surrounded by ore near the contact.

During the year difficulty was experienced in getting vessels to transport the ore to the United States on account of the general shortage of ships due to the war. The closing of the Panama Canal by landslides from September, 1915, to April, 1916, also seriously interfered with the ore shipments.

During the year the Bethlehem Steel Co., investigated other similar deposits of iron ore in Chile as did also another party. It is improbable, however, that any other iron-ore property will be opened for up several years to come.

The people of Chile are still hoping that some company will acquire some of the country's iron-ore deposits and put up blast furnaces and steel works on native soil to supply them with the iron and steel needed in the country. The lack of coking coal in the country seems to have thus far been the greatest obstacle and to date there is no indication that much Chilean iron ore will be used in Chile for the development of a local iron and steel industry.

China (By T. T. Read).—The only Chinese company, the Han-Yeh-Ping Iron & Coal Co., which was noted last year as planning to build a new plant nearer its iron mines, at Tayeh, in Hupei, has not yet begun actual construction, doubtless owing to the difficulty of financing during the war, and also because of the questions regarding the control of this company raised by the Japanese ultimatum delivered last May. The customs figures for 1914 show an export of 300,000 metric tons of iron ore and 60,000 tons of pig and manufactures of iron and steel, which is about the average of recent years. The joint Chinese-Japanese company at Pen-hsi-hu, in Manchuria, which has a capacity of 150 tons a day, has not yet developed its operations to full capacity. Japanese operations in Shantung, where the Germans were planning development just before the war, have not yet brought in any new productions.

Cuba.[1]—Cuban shipments of ore in 1915 were considerably checked because of transportation difficulties. Total shipments to the United States for the year were approximately 830,000 tons, or only slightly in excess of those of 1914, which were the smallest since 1908. Shipments in recent years were as follows: figures for 1915 and 1914 are estimated:

Year.	Total.	South Coast.	North Coast.
1915	830,000	520,000	310,000
1914	850,000	580,000	270,000
1913	1,582,431	1,090,718	491,713
1912	1,397,797	951,621	446,176
1911	1,163,714	775,922	387,792
1910	1,462,498	1,154,798	307,700
1909	936,132	936,132	....
1908	620,836	620,836	....
1907	650,174	650,174	....
1906	640,574	640,574	....

The Spanish-American Iron Co. as usual, shipped a large part of this tonnage. From Mayari, or North Coast workings, were sent 308,896 tons and from the Daiquiri, or South Coast deposits, 245,590 tons were forwarded. The total was slightly less than in 1914, and only about one-third of the combined shipments for 1913. No important extensions of mining operations are contemplated, but explorations are being continued.

The Juragua Iron Co., a subsidiary of the Bethlehem Steel Co., shipped in 1915, 212,000 tons from the Daiquiri district. This compares with about 220,000 tons in 1914, 369,213 in 1913, and 260,094 in 1912.

The Ponupo Manganese Co. shipped approximately 200,000 tons from the south coast district, sales made the year previous at a basis of 7 cts. tidewater for Bessemer grade, and 8 cts. for low-phosphorus material. In the latter part of the year, the demand for low-phosphorus enabled sales to be made for 1916 shipments at 11 cts. per unit, a new high mark.

An important development in the Cuban situation was the acquirement in December by the Midvale Steel and Ordnance Co. of the properties of the Buena Vista Iron Co. These deposits are in the southeastern end of the island near Moa Bay. They have never been developed. The reserves are estimated at 300,000,000 tons of nickel-bearing ore of dry-analysis content; iron 56 per cent., nickel 1, silica, 5, phosphorus 0.018, and sulphur 0.3 per cent.

France.—The iron and steel industry of France is largely centered in the war zone, and the demoralization occasioned has left a dearth of statistics for the war period. So far as data are available, the production of iron and steel is noted below:

[1] *Iron Tr. Rev.*, Mar. 16, 1916.

PIG-IRON PRODUCTION IN FRANCE
(In metric tons)

	1906.	1907.	1908.	1909.	1910.	1911. (a)	1912. (a)	1913.
Foundry......	591,275	651,700	695,527	749,247	760,622	836,454	825,682	957,145
Forge........	741,571	673,885	543,067	538,053	556,767	586,496	568,164	565,133
Bessemer.....	149,971	122,046	118,121	118,002	104,966	104,265	117,221	161,464
Basic.........	1,784,726	1,988,343	1,949,107	2,172,718	2,549,908	2,777,261	3,304,518	3,546,057
Special irons..	51,489	152,975	85,328	54,085	60,196	122,113	56,407	81,517
Total.......	3,319,032	3,588,949	3,391,150	3,632,105	4,032,459	4,426,469	4,871,992	5,311,316

(a) As reported by the Comité des Forges.

IRON AND STEEL PRODUCTION IN FRANCE
(In metric tons)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.
Wrought iron.	747,900	687,249	563,745	519,200	501,100	462,681	(e)450,000	....
Steel ingots...	2,436,322	2,766,773	2,727,617	3,034,571	3,506,497	3,680,613	4,078,352	4,419,241
Finished steel.	1,454,456	2,261,217	1,894,022	2,043,022	2,684,000	2,638,484	3,028,799	2,993,050

(e) Estimated.

STEEL PRODUCTION IN FRANCE
(Metric tons)

	Bessemer.		Open-hearth.	Crucible and Electric.	Total.
	Acid.	Basic.			
1904	....	1,334,798	745,756	....	2,080,354
1905	119,526	1,345,511	775,247	....	2,240,284
1906	108,037	1,418,525	834,815	....	2,371,377
1907	78,771	1,669,757	1,001,463	16,782	2,766,773
1908	77,581	1,632,296	1,002,798	14,951	2,727,657
1909	76,981	1,853,327	1,080,912	23,351	3,034,571
1910	81,293	2,131,676	1,148,548	28,792	3,390,309
1911	75,158	2,389,352	1,185,345	30,758	3,680,613
1912	73,917	2,664,610	1,320,462	37,363	4,078,352
1913	76,816	2,931,072	1,368,067	43,286	4,419,241

The French steel industry and its outlook are described by H. H. Campbell.[1] Almost all of the iron ore is in the province of Meurthe et Moselle, on the extreme eastern frontier. There are three separate ore fields; Longwy in the north; Nancy in the South; and Briey in the center; the latter district being only a few miles from Metz. In most places the ore is near the surface but there are some deep mines in the Briey field. The last-named is much the largest of the three, and produces about two-thirds of the output. The whole district raises about 15,000,000 tons per year, or over 90 per cent. of the total ore output of France. Large amounts of ore were exported to Germany, Luxembourg and Belgium.

[1] *Iron Age*, May 18, 1916.

There are plentiful reserves of good ore, and much in addition of inferior quality. The ore of the Briey field is of fairly regular composition. Much is of high lime-content, and is thus self-fluxing. This offsets in large degree its relatively low iron-content. Phosphoric acid is present to such degree that a pig iron of 1.70 per cent. phosphorus results. This is used almost altogether in the basic Bessemer converter. The iron-content, dried, varies from 33 to 40 per cent., the leaner ore having a lime-content of 16 per cent. Calcination brings up the iron grade by several per cent.

Most of the steel made in France is manufactured near the ore mines, about two-thirds being the product of the basic Bessemer process.

Imports of iron ore in 1915 were 397,348 metric tons, against 1,044,160 tons in 1914. Exports were 94,864 tons in 1915, compared with 4,828,592 tons in 1914.

Imports of iron and steel were 927,358 metric tons in 1915, and 109,550 tons in 1914. Exports for the same years were 152,117 and 419,142 tons, respectively. The 1915 imports included 175,201 metric tons of pig iron, against 21,900 tons in 1914 and 50,345 tons in 1913.

Germany.[1]—There has been a steady revival in the iron and steel industry during 1915. Cutting off of some of the important sources of iron ore supplies has been a handicap, since the blast furnaces of certain districts have been dependent to a considerable degree upon importations. In 1913 the imports of iron ore into Germany from various countries were as follows: Sweden, 4,564,000 tons; France, 3,811,000 tons; Spain, 3,632,000; Russia, 489,000; Algeria, 481,000; Norway, 303,000; Greece, 147,000; Tunis, 136,000; Newfoundland, 121,000; Austria, 106,000; other countries 161,000 tons; a total of 13,951,000 tons. This was about 25 to 30 per cent. of the blast-furnace requirements. For the first half of 1914, importations of ore were about at the 1913 rate, being 6,748,052 metric tons for the period. Statistics of iron importation since the beginning of the war are lacking. All of the above sources of supply, however, are cut off except Sweden, from which heavy shipments have been received, and those French and Belgian mines in the Longwy district which are now in the hands of the Germans and are being operated by them. In the last half of 1915, blast furnaces in Germany were supplied with iron ore more regularly and in larger volumes than in preceding war months.

Pig-iron production has steadily increased. Output by months for the past 3 years is noted below; for 1915 it was 39 per cent. less than that of 1913, which was a record year. Present producing capacity is about 20,000,000 tons annually:

[1] *Iron Age*, May 11, 1916.

	Metric Tons.		
	1913.	1914.	1915.
January	1,611,345	1,566,505	963,790
February	1,493,877	1,445,511	946,191
March	1,629,463	1,602,896	1,098,311
April	1,588,701	1,534,429	1,012,824
May	1,643,069	1,607,193	1,044,107
June	1,609,748	1,531,313	1,080,786
July	1,648,818	1,564,345	1,138,651
August	1,640,016	586,661	1,158,702
September	1,599,849	580,087	1,174,350
October	1,653,051	729,822	1,215,287
November	1,588,985	788,956	1,192,817
December	1,611,250	853,881	1,165,465
Total	19,309,172	14,389,547	11,790,199

Production of pig iron by kinds for several years past is noted below. Steel pig includes ferromanganese, spiegeleisen, ferrosilicon, and similar alloys:

PRODUCTION OF PIG IRON IN GERMANY
(In metric tons)

	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Foundry iron	2,254,644	2,491,919	2,968,810	2,881,059	3,355,177	3,640,074	2,494,527	2,286,670
Forge iron	635,228	652,306	644,992	689,881	525,423	489,783	370,257	278,684
Steel pig	934,940	1,099,779	1,327,196	1,547,480	2,201,489	2,599,887	1,996,786	1,793,865
Bessemer pig	361,472	412,118	471,366	377,051	388,855	368,840	237,988	187,522
Thomas pig	7,627,227	8,261,538	9,338,961	9,785,056	11,397,965	12,193,336	9,289,989	7,243,458
Total	11,813,511	12,917,653	14,793,325	15,280,527	17,868,909	19,291,920	14,389,547	11,790,199

The following table gives the production according to districts:

PRODUCTION ACCORDING TO DISTRICTS

	Tons, 1913.	Tons, 1914.	Tons, 1915.
Rhenish-Westphalia	8,209,157	6,610,119	5,165,618
Siegerland and Hessen-Nassau	994,927	702,436	789,650
Silesia	994,604	853,957	777,625
North and Central Germany	1,001,321	734,659	602,826
South Germany and Thuringia	320,456	266,065	234,669
Saar District	1,370,980	954,738	801,597
Lorraine and Luxemburg	6,417,727	4,267,573	3,407,946
Total	19,309,172	14,389,547	11,789,931

Steel output for 1915 is reported as 13,187,616 metric tons, a decrease of 1,785,490 tons, or 16 per cent., compared with 1914, and 5,771,203 tons, or 30.4 per cent., compared with the record year 1913. Itemized figures of steel production are as follows:

PRODUCTION OF STEEL IN GERMANY
(In metric tons)

	1912(a).		1913.		1914.		1915.	
	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.	Acid.	Basic.
Converter ingots...	187,179	9,794,300	155,138	10,629,697	100,617	8,269,600	165,290	6,528,146
Open-hearth ingots	295,256	6,871,896	380,155	7,592,901	361,564	6,518,874	243,111	5,376,931
Special steels......	153,367	....	200,928	....	184,432	....	229,693	....
Total (b).......	635,802	16,666,196	736,221	18,222,598	646,613	14,973,106	831,120	12,406,526

(a) As reported by the German Iron & Steel Union. (b) Includes direct castings.

Germany's rolling mills in 1915 produced 11,243,360 metric tons against 13,165,589 tons in 1914 and 16,968,950 tons in 1913. The output of various products, divided into pre-war and war periods for comparison, is given in metric tons as follows by the German Association of Iron and Steel Producers:

Descriptions.	1914.		1915.	
	Jan.–July.	Aug.–Dec.	Jan.–July.	Aug.–Dec.
Semi-finished for sale....................	1,593,984	435,296	911,934	730,017
Railroad materials....................	1,274,375	592,711	868,794	555,754
Shapes....................	946,852	245,394	487,170	279,483
Bars....................	2,638,139	898,762	1,849,168	1,479,517
Hoops....................	277,124	91,790	149,885	115,254
Wire rods....................	707,594	219,438	388,374	362,560
Plates....................	817,468	355,498	548,020	418,878
Sheets....................	528,692	210,113	352,671	276,024
Tin plates....................	51,333	34,236	52,444	40,307
Tubes....................	454,927	155,712	255,778	204,987
Rolling stock....................	199,000	78,048	112,304	79,776
Forgings....................	122,488	72,637	126,512	110,168
Other manufactures....................	88,413	75,565	226,603	260,978
Total....................	9,700,389	3,465,200	6,329,657	4,913,703

1913 total....................	16,898,950
1914 total....................	13,165,589
1915 total....................	11,243,360

The average monthly production in the 7 peace months of 1914, January–July, was 1,385,770 tons against 904,237 tons for the same period in 1915, or about 65 per cent. of the peace output. On the other hand, the average production of 693,040 tons from August to December, 1914, compares with an average of 982,741 tons per month in the same 5-month period in 1915, an increase of about 42 per cent. and about 71 per cent. of the average peace output.[1]

In the latter part of 1915, 231 steel plants were in operation, against 242 during 1914. There was a heavy demand for special and quality steels for shell and munition purposes, and the output of electric steel reached 87,262 tons in 9 months, almost equaling the total of 89,336 tons

[1] *Iron Age*, June 22, 1916.

for the entire year 1914. The number of electric furnaces was 53, an increase of 7 during the year.

Prices of leading iron and steel products in Germany on July 1, 1914, and Sept. 1, 1915, are noted below:

Kinds of Products.	Market Prices in Dollars per Metric Ton.	
	July 1, 1914.	Sept. 1, 1915.
Hematite pig iron	18.68	27.37
Foundry I	17.73	22.37
Foundry II	16.78	21.16
Luxemburg pig iron	14.28	17.73
Ingots	19.64	24.40
Siemens-Martin ingots	20.83	29.16
Billets	22.61	27.37
Siegerland ore	2.38	4.57
Siegerland spar	4.40	5.83
Bar iron	22.37	33.32
Weld iron	31.65	38.79
Strap iron	27.37	40.46
Black sheet	23.32	35.70
Boiler plate	25.70	38.08
Universal sheets	27.37	45.22
Rolled wire	26.18	33.32
Wire nails	27.96	42.84
Steel shapes	25.70	30.94

Great Britain.—Practically the entire steel-making facilities were concentrated on production for war purposes, with general requirements put off to a more convenient season. It has been a year of extraordinary prices in all finished materials, but there has not been the same condition, with regard to raw materials. Manufacturing difficulties have been prevalent, due to scarcity of labor and fuel, transportation congestion and government restriction and control.[1]

Pig-iron prices in the Cleveland district have been rather disappointing. At the close of 1914, Cleveland iron was quoted at $12.96. Prices rose slightly in the first 3 months of 1915, with a decided upward movement at the end of March, and a continuation in April, with selling at $16.32. This was followed by a reaction to $15.84 at the close of the first half year, and a large number of furnaces were blown out in July due to excess of supply over demand. In the autumn, competition was severe, with prices at about $15.36. Recovery came at the close of the year, and pig-iron prices advanced in December to $17.32.

Steel-making irons have experienced very much better conditions. During the year, northeast hematite pig advanced from $18 to $30, and northwest material from $16.32 to $29.28, marking record increases for a like period. Great consumption of steel for armor plate, guns, etc., created an immense demand for the hematite irons, and stocks of steel-making pig iron have been practically nil throughout the year.

Puddled-iron products have soared in price, from an average price of $35.54 at the close of 1914, to $50.08 in the latter part of 1915, a rise of $14.54 for the period.

[1] J. Horton, *Iron Tr. Rev.*, Jan. 6, 1916.

Semi-finished steel has experienced the full effect of the war boom. In January, 1915, beams were offered at $36, and open-hearth billets at $26.40. At the close of the year, it is difficult to even approximate the selling figure since some products are not obtainable at any price. Small lots of Bessemer billets are obtainable at $62.40 per ton; treble the ante-war prices. It is probable that $72 represents the price of beams and angles.

Imports of iron ore into Great Britain in 1915 are reported as 6,203,161 gross tons, compared with 5,704,748 tons in 1914, and 7,442,249 tons in 1913.

Domestic output of iron ore was 14,867,582 gross tons in 1914, and 15,997,328 tons in 1913. In these years iron-ore consumption is reported as 22,470,749 and 25,707,518 tons, respectively.

Production of pig iron in 1915 was 8,793,659 gross tons, which was 212,239 tons, or 2.4 per cent., less than 1914, and 1,688,258 tons, or 16.1 per cent., less than 1913, a record year. Detailed statistics are given in the following table, classified according to kinds of iron:

	1912. Tons.	1913. Tons.	1914. Tons.	1915. Tons.
Forge and foundry	3,431,727	3,943,139	3,430,448	2,597,638
Bessemer and hematite	3,408,386	4,057,700	3,235,403	3,564,276
Basic	1,771,771	2,125,689	2,003,693	2,272,684
Spiegel, ferro, etc	277,240	355,389	336,354	359,065
Total	8,889,124	10,481,917	9,005,898	8,793,659

Scotland, The Northern Coast, Cumberland and South Wales, make all the low-phosphorus iron (Bessemer and hematite). Basic pig is largely made by the Northeast Coast (Middlesboro) and Lancashire districts.

Production of pig iron for a number of years past has been as follows:

	Tons.		Tons.
1906	10,149,388	1911	9,718,638
1907	9,923,856	1912	8,889,124
1908	9,289,840	1913	10,481,917
1909	9,664,287	1914	9,005,898
1910	10,217,022	1915	8,793,659

The British output of steel ingots for 1915, according to statistics published by the Iron, Steel and Allied Trade Federation, was 8,350,944 gross tons. This is the largest output for the past 10 years or more. The production of various grades for the past 6 years was as follows, in gross tons:

	Acid Bessemer.	Basic Bessemer.	Acid Open-hearth.	Basic Open-hearth.	Total.
1910	1,138.103	641,012	3,016,830	1,578,536	6,374,481
1911	887,767	573,373	3,131,118	1,869,354	6,461,612
1912	980,662	541,825	3,365,570	1,908,087	6,795,144
1913	1,048,772	551,929	3,811,382	2,251,793	7,663,876
1914	797,072	482,444	3,680,848	2,874,749	7,835,113
1915	821,408	479,816	4,090,752	2,958,968	8,350,944

The total Bessemer output last year, 1,301,224 tons, was larger than in 1914, but lower than any other recent year; while the open-hearth output of 7,049,720 tons was larger than in any previous year. The production of puddled bars last year was 932,906 tons, considerable decrease from 1914.

In 1915, 61 Bessemer converters and 489 open-hearth furnaces were in operation; and 35 converters and 103 open-hearth furnaces were idle.

During 1915 Great Britain exported 3,250,299 gross tons of iron and steel, as compared with 3,977,468 tons in 1914, and 5,049,090 tons in 1913. Complete data are given below:

IRON AND STEEL EXPORTS, UNITED KINGDOM
(In tons of 2240 lb.)

	1909.	1910.	1911.	1912.(a)	1913.(a)	1914.	1915.
Pig iron	1,136,369	1,205,863	1,204,319	1,124,815	1,097,009	780,691	508,540
Wrought iron	170,189	141,747	138,089	142,461	137,335	90,405	....
Sheets	494,826	597,117	617,557	762,244	762,744	566,601	286,466
Plates	167,797	250,867	267,691	282,898	273,051	199,878	....
Rails	571,524	485,693	370,543	412,127	509,105	443,636	242,289
Steel shapes, etc.	305,530	369,020	347,828	361,992	368,498	300,653	489,464
Tin plates	439,804	483,020	484,355	480,910	495,246	435,497	368,000
All other kinds	932,024	1,208,578	1,088,727	1,211,102	1,295,453	1,071,546	1,252,540

The 1915 rail export is the lowest for 10 years, and that for 1909 the highest. Heavy shipments of pig iron were made to Italy and France in 1915; 119,960 and 145,028 tons, respectively; and of steel bars to France—349,297 tons.

Imports of iron and steel products are reported as 1,295,387 gross tons in 1915, against 2,343,173 tons in 1913. Billets and sheet bars amounted to 440,000 tons in 1915 and 850,000 tons in 1913. Of a total tonnage of 427,996 of billets, blooms and slabs imported into Great Britain in 1915, 349,046 tons were furnished by the United States. Thus the latter country supplied over 80 per cent. of British imports of semi-finished steel, capturing a place formerly held by Germany. Before the war the United States furnished less than 20 per cent. of Britain's imports of semi-finished steel.

The district around Middlesborough on the Northeast Coast is the most important iron center in Great Britain, mining nearly 40 per cent. of all the ore raised in the kingdom, producing nearly 40 per cent. of the pig iron, receiving nearly half the foreign ore and making about one-third of the steel. Glasgow, the West Coast and Cardiff follow, these three districts together making one-third of the total pig iron and a slightly greater proportion of the steel. The four districts combined receive nine-tenths of the foreign ore and make from two-thirds to three-quarters of all the pig iron and steel produced in Great Britain.[1]

In 1913, which was the last normal year, almost exactly 16,000,000 tons of ore was raised in Great Britain; and of this total 14,200,000 tons contained only 30 per cent. of iron or less. This lean ore accounts for half the pig iron made in Great Britain; but it does not account for half the steel, because acid steel formed 64 per cent. of the total, and three-quarters of this, or one-half the total production, had its origin in imported ores. So today Great Britain is dependent to a great extent on foreign raw material; but the increasing use of the basic open-hearth furnace may make the country more self-sustaining and make vast stores of ore, which are low in iron and high in phosphorus, available for the making of steel.

Holland.—Imports of iron and steel products in the past 2 years are as follows:

	1914. Metric Tons.	1915. Metric Tons.
Pig iron	208,562	46,608
Finished iron and steel	636,197	523,033
Steel bars and rods	166,877	33,258
Rails	49,286	26,222

Exports of pig iron were 4055 metric tons in 1915, compared with 126,426 tons in 1914.

India.—Output of iron ore in India in 1914 is given as 441,674 gross tons. The output was practically stationary for many years at the average of about 80,000 tons per annum until 1911, when the average output was almost quadrupled, owing to increased production by the Tata Iron & Steel Co. at Sakchi. This compay produced, in 1914, 162,462 tons of pig iron, 63,404 tons of steel, 75,904 tons of blooms, 55,443 tons of rails and beams, and 6704 tons of bars.

Imports of finished iron and steel into British India in 1915 were only 298,042 gross tons as compared with 465,498 tons in 1914. The largest items were 50,218 tons of galvanized sheets in 1915 and 129,622 tons in 1914.

Japan.—Japanese iron and steel trade has been favored by the war, but a depression prevails in pig iron for domestic use. The country has only a few iron mines of relatively small importance. The present demand for pig iron is about 1,000,000 tons per year, about one-third of

[1] H. H. Campbell, *Iron Age*, May 4, 1916.

which can be provided by Japanese works by importation of 300,000 tons of iron ore from China.[1]

Production of iron and steel in 1914 was 320,558 metric tons, of which 230,928 tons was made by the Imperial Steel Works. From January to September, 1915, there was a decrease of general production of 19 per cent., and an increase by the Imperial Works. Output for the year is estimated at 323,000 tons, 250,000 tons of this being produced by the government works.

At the close of 1915, prices on many products were over 100 per cent. higher than prior to the war, due to the difficulty of obtaining material in the available markets, the increase in freight rates, and the utilization of domestic output in munitions manufacture.

Japanese papers state that a boom is being experienced in the steel and metal trades of the country and give some prominence to a movement for the organization of a new steel plant, with $10,000,000 capital, to be located in Kyushu. An adequate supply of good ore from China is counted on.

Plans for a third extension to the plant of the Government Iron Works at Edamitsu are reported, to be carried out immediately on the completion of the second extension. Capital for the contemplated extension is $17,928,000, to be spread over 5 years, with the intention of increasing the annual production 300,000 tons. Arrangements are understood to have been made for the purchase of all the required machinery through government agencies overseas. Ores are imported from China, Chosen and other continental mines. The output of steel for 1916 will be probably 330,000 tons.

Another report is that a large iron works is to be established in Hokkaido. The increase of Japan's capacity for producing iron and steel is considered most urgent. A new iron mine near Kuchian, Hokkaido, estimated to contain 7,000,000 tons of ore, is attracting attention.[2]

Korea.[3]—A new pig-iron furnace is to be erected by the Mitsu Bishi Co., of Tokio, Japan, at Kenjiho, near Pyeng Yang, Chosen (Korea), within the next 2 years, at an estimated cost of 5,500,000 yen ($2,750,000). It is understood that bids have been invited from various companies in England, the United States and Germany; and also that one American company has already entered a bid. It is planned to erect two pig-iron furnaces, with a capacity of 150 tons each per day. The product is to go mainly to the steel works at Wakamatsu to replace the pig iron now being imported from China. The company owns both coal and iron mines in the vicinity of the proposed foundry, the iron ore from which is said to be

[1] *Eng. Min. Jour.*, Jan. 15, 1916.
[2] *Iron Age*, Mar. 30, 1916.
[3] *Min. Eng. World*, Mar. 13, 1915.

very similar to the ore found in the Alabama mines in the United States.

Philippines.—A recent survey of the Surigao iron ore deposits has proved a reserve of 500,000,000 tons, similar to the Mayari ores of Cuba. The location is such that a large proportion has possibilities of profitable mining. The ore occurs as a surface mantle varying in depth up to 60 ft., and consisting of hydrous oxides of iron in the form of clay. Sintering and agglomeration would be necessary to drive off moisture and lump the ore for blast-furnace use. After treatment, the iron-content would average about 54 per cent.; sulphur and phosphorus are very low.

The deposit is at the present time more of a potential than actual reserve, since there is not sufficient demand for iron and steel in the Philippines to warrant exploitation. Again, other large deposits of richer iron ore are known to exist in the country, and in more convenient locations for working. All attempts to exploit Philippine iron-ore deposits to date have failed.

Russia.—The iron industry has been hard hit by the war. The shortage of labor and cars has been a serious drawback.

Russia's pig-iron production in 1915 is estimated at 3,696,560 metric tons, or 564,448 tons less than that of 1914 and 851,816 tons less than that of 1913, according to a recent bulletin issued by the central committee of industrial mobilization of Petrograd, Russia. Leaving out the district of Poland and considering only South Russia, the Urals and the central district, the 1915 output was 3,648,344 tons against 4,003,534 tons in 1914 and 4,135,324 tons in 1913.

Out of a total consumption of 4,741,240 tons of pig iron in 1913 the bulletin states that 4,548,376 tons, or 96 per cent., was made in Russia. A diminution of imports late in 1914 did not cause anxiety, but later, owing to the comparative shortage of materials, the government decided to procure, principally from the United States, 321,000 tons of rails, 80,000 tons of wire and 105,000 tons of axles, tires, etc.

The output of semi-finished steel in 1915 is put at 4,018,000 tons against 4,243,008 tons in 1913 and of manufactured iron and steel at 3,214,400 tons against 3,535,840 tons in 1913.

The pig-iron production could have been raised to 4,500,000 tons if deliveries of raw materials could have been made to 15 blast furnaces out of service in South Russia.

Finnish capitalists have under consideration the construction of a railway line to large deposits of high-grade magnetite and hematite in Finnish Lapland. The ore is of a grade equal to the deposits of Swedish and Norwegian Lapland.

[1] *Iron Age*, Apr. 13, 1916.

Sweden.—The iron market of Sweden experienced a marked improvement over the depression noted during 1914. Demand for the general range of products was good, both for domestic consumption and for export.

Swedish pig-iron production in 1915, according to the Swedish Ironmasters' Association, was 767,600 tons; in 1914 it was 635,100 tons and in 1913, 730,300 tons. The open-hearth steel output was 498,400 tons against 407,600 tons in 1914 and 469,400 tons in 1913, while that of Bessemer steel was 90,400 tons in 1915, 93,000 tons in 1914, and 115,800 tons in 1913. Rolled iron and steel output in 1915 was 401,900 tons. On Dec. 31, 1915, 101 blast furnaces were active (65 on Dec. 31, 1914); 155 puddling hearths (134 in 1914); 14 Bessemer converters (6 in 1914) and 60 open-hearth furnaces (45 in 1914).

Iron-ore exports last year were 5,994,000 tons, which compares with 4,681,000 tons in 1914 and 6,440,000 tons in 1913. Ferro-silicon production was about 10,700 tons against 10,000 tons in 1914 and 9600 tons in 1913; but that of spiegeleisen was only 1100 tons against 11,800 tons in 1914 and 2600 tons in 1913.

Iron and steel imports in 1915 declined 8800 tons, or from 238,800 tons in 1914 to 230,000 tons.

All the above production figures are metric tons.[1]

Statistics are noted below, in metric tons.

	1913.	1914.	1915.
Production:			
Pig iron	730,300	635,100	767,600
Wrought-iron blooms	158,500	113,300	119,200
Converter steel	115,800	93,000	90,400
Open-hearth steel	469,400	407,600	498,400
Rolled iron and steel	....	....	401,900
Exports:			
Pig iron, spiegel, etc	225,500	179,800	305,100
Puddled blooms and bars	198,200	131,700	187,000
Other finished forms	78,900	71,300	96,800
	502,600	382,800	588,900

Technology

The stagnation which marked the iron and steel industry in 1914, prevailed during the first half of the year 1915; then began an activity which forced production to the limit of capacity in the last half of the year. Economy was the watchword of the earlier period; while in the latter, the strain imposed by high-speed operation absorbed all surplus energy. The industrial changes of the year were extreme, and almost epoch-making in character; technical advances, on the other hand, were rela-

[1] *Iron Age*, Apr. 6, 1916.

tively slight. In this country industrial conditions were at the two extremes; where there is only lukewarm financial support of work which at the time can show little return on the credit side of the ledger, and where there is little energy or talent to spare along lines other than those of turning out maximum tonnage. Conditions were even worse in the countries involved in the war since much of the available talent was needed at the front, and the rest found employment in fields other than those of technical investigation.

However, the war and business conditions forced development along lines that would not have been attempted in the ordinary course of events, or at any rate would have required considerably longer periods to reach their present status. In this country the supply of some of the auxiliaries required in steel-making became cut off or much curtailed, and while of small tonnage compared with steel, were so vital in its manufacture that serious thought and experiment were devoted to modifications of customary practice. The high values of certain by-products have fostered the development of recovery installations and correlated utilization works which might otherwise have taken years for consummation. Naturally there is a dearth of results of technical investigation from the countries at war.

Fuels.—The by-product coking industry has made steady progress in recent years. All plants were equipped to recover the gas, tar and ammonia; a few went further and separated the benzol to an amount of 2 to 2½ gal. per ton of coal coked, with the purpose of placing it on the market in competition with gasoline at usual prices. The rise in the price of gasoline during the past year stimulated the efforts toward benzol recovery; again the price of benzol rose in greater degree because of its utilization in dye-stuffs and explosives manufacture. In particular, the soaring price of toluol, a petroleum derivative of value in explosives manufacture, made recovery from coke-oven by-products especially attractive, since ¼ to ½ gal. of toluol may be extracted per ton of coal coked and marketed at a price normally about 40 cts. per gal., but which rose to several times this figure during the year. Benzol-recovery plants were completed in 1915 by the Tennessee Coal, Iron & Railroad Co. at Birmingham, Ala.; Woodward Iron Co., Woodward, Ala.; Lackawanna Steel Co., Buffalo, Zenith Furnace Co., Duluth, Minn., Carnegie Steel Co., Farrell, Pa., Indiana Steel Co., Gary, Ind., Lehigh Coke Co., South Bethlehem, Pa., Republic Iron & Steel Co., Youngstown, O., Dominion Steel Co., Sydney, N. S., a total capacity of about 50,000 gal. of benzol per day. Plants are under construction or contract by the Illinois Steel Co. at Joliet, Ill., Citizens Gas Co., Indianapolis, Ind., Benzol Products Co., Marcus Hook, Pa., Crows Nest & Pass Coal Co., Fernie, B. C., The Newport Hydro Carbon Co., backed by the Newport Mining Co., is erecting a plant at Carrollville, Wis., to manufacture coal-tar products.

There has been considerable interest in dye-stuffs and coal-tar products, due to the dearth of the customary German supply, and if American manufacturers become convinced that such industries can be put upon a permanently profitable basis, there should be much development, with consequent stimulus to by-product coking.

C. Otto has studied new method for the determination of coke-oven heat balances.[1] In view of the extensive application of coke-oven gases, the need for precise scientific data concerning the heat conditions of coke ovens calls for a careful investigation of these, and the author has endeavored to supply the want.

The cement gum is finding application in the repair of coke ovens, and such repairs can be made while the oven is in service. A cement of 80 to 85 per cent. silica, similar to that used for joint construction, is sprayed under high pressure and penetrates all crevices, making a tight seal.

A Morgan gas producer of new design has been developed.[2] It is of the well-known grateless type with water pan. Instead of poking or breaking up the fuel-body, the fire is left undisturbed. A stationary top with revolving body and pan provide for even distribution of coal, and proper removal of ash. Combustion is evenly maintained by a gentle air blast from a hollow ring in the side walls, and three radial arms. Gasification of 3000 lb. of coal per hr. is effected without hand labor.

Due to the scarcity of coal and the necessity of getting the maximum amount of by-products, certain iron works in Germany have been using small coke, mixed with equal parts of coal, in their gas producers, and have also experimented with producers fed with coke alone.[3]

Refractories.—Scarcity of foreign magnesite supplies has served to revive interest in domestic supplies.[4] In California a railroad has been built to deposits in Sonoma County, providing transportation to San Francisco Bay, 50 miles distant. A kiln with an output of 30 tons of calcines per day is operating, and a second of double capacity is under construction.

P. Goerens and J. W. Gillu[5] have investigated the heat conductivity of fire-brick, up to temperatures of 1000° C. Silica, fire-clay and carbon have a coefficient of conductivity which increases with temperature rise; while for magnesia there is a negative coefficient. The coefficient of

[1] *Stahl u. Eisen*, May 6, 1915.
[2] *Iron Tr. Rev.*, July 22, 1915.
[3] *Stahl. u. Eisen*, vol. 25, 1915.
[4] *Iron Age*, Apr. 16, 1916.
[5] *Ferrum*, vol. **12**, 1914–15.

heat conductivity decreases the greater the degree of porosity of the material, while materials of high specific gravity are good heat conductors.

G. Dougill, W. J. Hodsman, and J. W. Cobb[1] have carried out an investigation along the above lines, and show the influence of temperature on the conductivities of magnesia and fire-clay brick by means of curves. The question of porosity and diffusivity is also discussed.

Similar researches on silica, fire-clay, and magnesite bricks have been conducted by B. Dudley.[2]

Iron Ore.—Beneficiation of iron ores has made progress during the year. New plants have been built for washing the ores of the western Mesabi and Cuyuna ranges.[3] Four plants are now in operation on the Mesabi and two on the Cuyuna range, while others are planned for beneficiating the siliceous ores. All installations are log washers, with the accompanying auxiliary crushers, screens, etc.

Experimental tests in concentrating Cuyuna ores have been conducted by the Minnesota School of Mines.[4]

The mechanical progress of smelting iron ores is discussed by B. F. Klugh.[5] Dwight-Lloyd plants are now built in sizes from 42 in. by 13 ft. to 60 in. by 30 ft., with capacities of 50 to 100 tons per 24 hr. for the small size, and 300 to 400 tons for the large. Much progress has been made in increasing the unit capacity of machines, and present installations have treble the output of the earlier types of corresponding size. There is a wide field for sintering and desulphurizing fine ores. Magnetite ores may be crushed fine enough to effect good separation magnetically, and the resulting concentrates may be sintered to give a cellular agglomerate of suitable size and structure for blast-furnace use. Sintering is well adapted to the waste paint rock ores of the Mesabi, with resultant enrichment to 52 per cent. of iron-content. Burnt pyrites is also well adapted to sintering in preparation for the blast furnace.

A flue-dust sintering plant is in operation at the works of the Indiana Steel Co. Gary, Ind.[6] There are two rotary kilns, each 9 ft. in diameter and 90 ft. long. The kiln turns about 1 r.p.m. and the flue dust which enters at the upper end slowly works its way down toward the discharge end. Coke-oven gas is burned at the discharge end. A scraper chain extending through the drum prevents the sinter from sticking to the walls.

Rotary roaster kilns of the cement type for iron ores are discussed by S. E. Doak.[7] This type of kiln is best adapted for fine ores having no

[1] *Jour. Soc. Chem. Ind.*, vol. **24**, 1915.
[2] *Trans. Amer. Electrochem. Soc.*, **27**, 285.
[3] *Min. Eng. World*, May 15, 1915.
[4] *Bull. Minn. School of Mines, Exp. Sta.*
[5] *Amer. Iron & St. Inst.*, Oct., 1915.
[6] *Iron Tr. Rev.*, May 20, 1915.
[7] *Bull. Amer. Inst. Min. Eng.*, Sept., 1915.

fuel-content, and is thus not so well suited for flue dust. The fine ore is nodulized and desulphurized satisfactorily for blast-furnace use, if the sulphur in the ore is not over 6 or 7 per cent. Kilns vary from 60 to 100 ft. in length, and 5 to 8 ft. in diam., and have a capacity of 1000 to 4500 tons per month. The fuel consumption is about 12 per cent. The The usual size of clinker is 80 per cent. on ⅛-in. mesh.

Magnetic concentration plants in the eastern United States were extended during the year. An experimental plant was operated at Sellwood, Ont., for the treatment of Moose Mountain ores, large bodies of which are controlled by American interests. The ores are crushed and ground fine, and separated magnetically in Ball-Norton machines. The pulp is dewatered and molded into briquettes, the wet pulp setting sufficiently to give a good bond.

The geological feature of the iron ore deposits at Daiquiri, Cuba, are described by J. F. Kemp and by W. Lindgren and C. P. Ross.[1]

Blast Furnaces.—Perhaps the greatest attention of blast-furnace operators has been given to more efficient conservation of the available heat, and more effective utilization of the gas through this heat saving and through better combustion.

A notable contribution to the literature of the subject is a paper by A. N. Diehl.[2] For effective utilization of blast-furnace gas it is essential to clean it. Ordinary dust catchers will reduce the dust to 3 gr. per cu. ft., while washing will reduce this to 0.2 gr. After washing, the gas must be cooled to remove the moisture to limits suitable for efficient combustion. Burners of the Bunsen type have long had attractions for use in stoves and boilers, but with dirty gas there was fluxing at the high temperatures attained. Equipment of stoves and boilers is described.

The Illinois Steel Co. has been in the forefront in effecting economics through efficient utilization of blast-furnace gas. The large plant at South Chicago, turning out 6000 tons of pig iron per day, has operated for over a year with a coke consumption of less than 1900 lb. per ton of iron; while some furnaces do better than 1800 lb. for long periods. In spite of this 30 per cent. of the gas is surplus with steam-driven blowers and 45 per cent. with gas-blown furnaces.[3]

The saving is credited largely to complete washing of the gas, which makes high blast heats possible with minimum gas in the stove, and consequent lessened coke; also there is better boiler efficiency through use of clean gas.

Present practice is to wash gas for stoves and boilers in a stationary two-stage vertical tower, one for each furnace. The gas

[1] *Bull. Amer. Inst. Min. Eng.*, Sept., Oct., 1915.
[2] *Amer. Iron & St. Inst.*, Oct., 1915.
[3] *Iron Age.*, Jan. 6, 1916.

passes upward through a rain from a hurdle washer, thence through contact baffles in the upper part of the tower. The wet gas is dried in horizontal baffle driers. The raw gas carrying from 5 to 25 gr. of dust per cu. ft. is cleaned to about 0.10 gr., at a cost of less than 1 ct. per 100,000 cu. ft. of gas treated.

It is now possible to operate with three stoves per furnace and get a blast heat of 1200° F.; and with four stoves, a temperature of 1400° F. is obtainable; these temperatures are 400° hotter than with dirty gas. Clean checker passages have made it possible to reduce the openings to 3½ or 4 in., compared with the old time 9-in. passage; thus there is greatly increased capacity per stove. Clean gas has also resulted in better boiler performance.

W. Mathesius[1] describes the practice with high blast heats in connection with Mesabi ores at the above plant. With these fine ores, blast temperatures of 800 to 1000° F. had become standard practice. At South Chicago furnaces have been running without difficulty and with low fuel requirements with blast temperatures from 1100 to 1300° F. These high temperatures necessitate proper combustion and efficient utilization of gas in the stoves. Clean gas and burners of the modified Bunsen type accomplish this object. The German method of forced-blast for the air required for combustion in the stoves makes it possible to operate with two stoves per furnace, with hourly changes from gas to air.

H. Blome[2] gives the results obtained by introducing oxygen into the blast-furnace blast.

In a noteworthy publication, A. E. Maccoun[3] reviews the progress in blast-furnace practice in this country. Quality, selection and treatment of ores and coke are discussed, as is the trend of development in construction and design of the stack. Completely worked out tables of heat balance and power consumption are given. Maximum efficiency of stoves is emphasized as making for lessened coke consumption, and this is accompanied by less flux requirement for the ash, less sulphur to remove, and better running because of more acid slags and more favorable operating conditions. But clean gas is necessary for the stoves, and washing is the effective method.

The advisability of efforts to reduce coke consumption to a low point, provided it is brought below 2000 lb. per ton, is questioned if there is opportunity for use of the surplus power in adjoining steel works.

The Cottrell process for the electrical precipitation of dust in gases

[1] *Amer. Inst. Min. Eng.*, Feb., 1915.
[2] *Stahl u. Eisen*, Oct. 7, 1915.
[3] *Amer. Iron & St. Inst.*, May 28, 1915.

has been applied to the dry-cleaning of blast-furnace gases by the Bethlehem Steel Co.

Blast-furnace slag is receiving attention as a useful by-product. In England bricks are made from slag which has been granulated by water or dry-crushed. The granulated slag is mixed with suitable proportions of slaked lime, and pressed in a mould. Air-drying or steaming at high pressure hardens the brick.

In this country slag finds its greatest outlet as filling, railroad ballast, and in cement manufacture. Some works are now crushing and sizing the material, and have broadened the field of usefulness, since it makes a desirable substitute for the various sizes of crushed rock which are used in concrete construction, in road building, and for railroad ballast.

The Croxton chain system has been devised for handling slag.[1] It is run into beds, across the bottom of which heavy chains are laid in parallel lines about 30 in. apart. The chains are lifted when the slag is cool and break it into large lumps, which can be handled with a grab bucket. These lumps are crushed and sized for the market.

The electric furnace for the reduction of iron ores has made no headway in this country during the year. The California furnace is reported to be working on ferro-manganese. In Sweden there are a number of electric iron-smelting furnaces in operation, with an annual production of about 50,000 tons of pig iron. All are using charcoal as reducing agent. In Norway efforts to smelt iron ore at Hardanger with coke as fuel, and by the "Electrometals" process, were not successful; while at the Tinfos Works satisfactory results were obtained with coke.[2]

The electric iron smelting works at Hagfors, Sweden, now comprises three furnaces, with a fourth under construction.[3] Some changes have been made in furnace lines and operating details. Circulation of gas is maintained at constant speed by fans, with a gain in working and economy. Details of construction and costs are given.

The Canadian Department of Mines has investigated the recent developments and present practice in electrothermic smelting of iron ores in Sweden.[4] The "Electrometal" type of furnace is in favor; this consists of a crucible or electrode chamber surmounted by a shaft, through which the ore descends, and in which is preheated and partially reduced by the gases. The latter are circulated by a fan. Descriptions of plants and furnaces and operating and cost details are given.

The very valuable series of articles by J. E. Johnson, Jr.,[5] dealing with the blast furnace, have been continued throughout the year. The

[1] *Iron Age.*, June 24, 1915.
[2] *Iron & Coal Tr. Rev.*, vol. **40**, 1915.
[3] *Engineering*, Aug. 6, 1915.
[4] A. Stansfield, Dept. Mines, *Bull.* 344.
[5] *Met. Chem. Eng.*, Jan. to Nov., 1915.

subdivisions treated were: handling iron and cinder; filling; auxiliaries and general arrangement; chemical principles, thermal principles. The first three sections are interesting descriptions of the development of mechanical appliances for the various purposes, and of present practice. The last two subdivisions deal with fundamental reactions involved in furnace operation, and in the control of the product; and with the heat balance and thermal efficiency of the furnace, and the weight of the various factors in affecting the fuel consumption of the furnace and economy of operation. The influence of dry blast and moisture is treated, and "Grüners ideal" of blast-furnace operation is upheld, in opposition to many authorities who maintain that it is not the ideal in present-day practice in this country with high-grade coke and ore and furnaces of large capacity.

Steel Works.—With a demand for steel which is exceeding the producing capacity of the country, the open-hearth facilities are taxed to the utmost. Bessemer plants have had only a partial burden, considerable of this tonnage resulting from an overflow demand which could not be satisfied by open-hearth plants, and which turned to Bessemer steel as being the most available product. The duplex process has made considerable progress in recent years; and in the present congestion it has attracted greatly increased attention because of meeting the situation. Idle Bessemer converters can be kept busy, open-hearth capacity may be greatly increased, and there is greater flexibility with regard to character of steel output and the raw materials—scrap and pig iron—for its manufacture.

Construction has been started at the plant of the Illinois Steel Co. at South Chicago, to adapt it to duplexing. The present equipment includes Bessemer and open-hearth furnaces. At the Gary works of the same company where open-hearth furnaces only have been installed and which fact was heralded a few years ago as virtually sounding the death knell of the Bessemer process in this country, plans have been consummated to install Bessemer converters to operate in duplex arrangement with the open-hearth plant. Similar arrangements are in prospect at other works, particularly plants having both types of furnaces.

The duplex process is discussed by several writers.[1] The usual combination is an acid-lined converter to desiliconize and partially decarbonize the pig iron; and subsequently furnish the heat, with removal of phosphorus, in a basic-lined open-hearth furnace. Proper arrangement of the units is essential for successful operation, in order that there shall be no loss of time or heat in the transfer of metal, and to reduce operating delays to a minimum. The duplex process shortens the open-hearth

[1] *Iron Age*, vol. **45**, 1915; *Met. Chem. Eng.*, Jan., 1915; *Amer. Inst. Min. Eng.*, Apr., 1915.

purification by about five-sixths of its usual duration, and yields as good a product.

The heat energy evolved during the Bessemer process, and the value of the gases issuing from the nose of the converter, are calculated. If all of the heat of these gases could be conserved and transformed and sold as electrical energy at 5 cts. per kw.-hr., steel ingots could be made as a by-product of an electrical power plant.[1]

Tests to determine to relative advantages and disadvantages of atomizing fuel oil with steam and air in open-hearth furnaces, have shown little difference in quality of metal, time of heats, oil consumption, oxidation losses, or temperatures secured. Since the cost of delivering the necessary air would be higher than that of the steam, the commercial advantage would seem to be employment of the latter as atomizing agent in open-hearth practice.[2]

As a result of several years of trial of three boilers utilizing the waste heat of open-hearth furnaces at the Illinois Steel Co.'s South Chicago works, 28 additional boilers were installed.[3] The three boilers have shown an average of about 280 boiler hp. each in conjunction with three 65-ton open-hearth furnaces About 28 per cent. of the heat in the coal charged to the producer is recovered in the large boiler installation. Boiler installation cost is about 25 per cent. higher than for coal-firing.

Interesting results are reported of an investigation of various gases with respect to their value as fuel for open-hearth furnaces. In the application of coke-oven gas, an important factor is the decomposition at high temperatures. Researches were conducted, and show that an important point in using coke-oven gas is the admission of sufficient excess air, to insure direct combustion of the hydrocarbons before separation takes place with precipitation of carbon.[4]

Lack of coal after the German occupation of Belgium, necessitated the use of tar as fuel for operating an open-hearth furnace at the Cockerill works.[5] The tar was sprayed by compressed air; the consumption being about 250 lb. per ton on 15-ton charges. The fuel cost with tar was only about half of that for the same furnace on heated producer gas and air, and slightly more than the cost with cold coke-oven gas and heated air. Operation was entirely successful over a long period.

The American Iron & Steel Mfg. Co., Lebanon, Pa., has utilized pulverized coal in open-hearth and various heating furnaces with extremely successful results.[6] For metallurgical furnaces only the best bituminous coal, with high volatile matter and low sulphur and ash, is

[1] *Iron Age*, May 18, 1915.
[2] *Amer. Found. Assn.*, Sept., 1915.
[3] *Iron Tr. Rev.*, June 3; Dec. 23, 1915.
[4] *Stahl u. Eisen*, July 8, 1915.
[5] *Iron & St. Inst.*, I, 1915.
[6] *Jour. Frank. Inst.*, Apr. 6, 1916.

desirable. Several large open-hearth furnaces have been operated on the regenerative principle for some time. The latest equipment is without regenerators, and with uni-directional heating; the waste heat is conserved by steam boilers. The extra fuel cost is more than offset by advantages of lessened fuel cost and simplicity of equipment and operation.

S. Cornell institutes a comparison between open-hearth furnace practice and the manufacture of commercial steels in the electric furnace.[1] The heat balances are based upon commercial furnaces of large size. To compete with the open-hearth furnace in the manufacture of tonnage products, electrical energy must be produced at a cost of 0.1 ct. per kw.-hr. whereas the present cost, using blast-furnace gas, is about 0.7 ct. per kw.-hr. at the lowest.

The electric furnace for steel-making has made great progress in the United States, the increase being from 41 furnaces to a total of 73 during the year. The Heroult type has made the greatest gain, from 19 to 43; the Snyder has increased in number from 7 to 14. The greater proportion of the furnaces is being used in the steel-casting industry, and for tool steel and other special steels of high quality. In this field the electric furnace will give a quality product at a cost lower than that of crucible steel. Much interest attaches to the announcement of the United States Steel Corporation that an additional 15-ton and two 20-ton Heroult furnaces will be installed at South Chicago, and a 15-ton furnace of the same type at the Duquesne works near Pittsburgh. The United States has already surpassed Germany as the leading producer of electric steels.

Ingot casting and reduction of piping continue to hold attention.[2] Two new casting methods have been described. The Kenney process employs a sinkhead surrounded by a dry sand sleeve to slow down the rate of cooling. The Gathmann ingot mould has the walls of the upper third very much thinner than the lower parts. The slower cooling of the top is claimed to materially reduce the crop.

The more important principles in the control of piping and segregation in ingots are discussed by H. M. Howe.[3]

There have been no radical developments in rolling-mill practice. Electric driving has continued its advances, but without material change in the status with respect to heavy drives.

The power requirements for rolling mills have been discussed by various writers.[4]

Quality of Iron and Steel.—The various committees of the American Society for Testing Materials were active formulating new specifications,

[1] *Met. Chem. Eng.*, Sept. 15, 1915.
[2] *Iron Tr. Rev.*, Aug. 19, 1915; *IronTr. Rev.*, Aug. 12, 1915.
[3] *Amer. Iron & St. Inst.*, Oct., 1915.
[4] *Stahl u. Eisen*, Apr. 22; May 13, 27, 1915; *Steel & Iron*, May 1, 1915; *Iron Age*, Aug. 5, 1915.

and in revising old ones. In particular, standards were proposed for automobile, vehicle, and railway springs, and mark the first attempt along these lines.

A committee of the society disagrees with the findings of the Bureau of Standards on finishing temperatures and properties of rails, in which the shrinkage clause in rail specifications is condemned.[1] The committee finds that there is no evidence that decided differences in quality of rails result from varying finishing temperatures in rolling. The shrinkage determination furnishes a satisfactory and convenient means of checking the finishing temperature.

Experiments of the Bethlehem Steel Co. upon rails rolled at various temperatures from 1652 to 2147° F. indicated no appreciable difference in grain size and no variations conformable with the temperatures; nor were the physical tests materially different for the several conditions. The microstructure was found to be more a function of the rate of cooling from above the critical temperature than of the finishing temperature itself.

M. H. Wickhorst has conducted tests for the American Railway Engineering Association on the influence of finishing temperature upon open-hearth rails. Complete tensile, drop test and metallographic results are tabulated. Finishing temperatures ranged from 695 to 850° C. Drop-test results were about the same in all cases, as were the results of slow bending and transverse tests. Lower finishing temperatures gave a somewhat finer-grain structure and a little greater elongation and reduction of area in the tensile tests. He also reports the results of tests to determine the effect of blooming mill methods on the ductility of rails.[3]

Investigations of the American Railway Engineering Association show that rail failures have decreased, with a gradual improvement since the studies were initiated in 1908. For each of 4 years, 1909 to 1912 inclusive, track failures of Bessemer rails have been approximately double those of open-hearth product. For 1909 rails, which have had 5 years of service, the failures have been 269 and 142 rails per 10,000 tons respectively, for the two classes of material.

P. H. Dudley considers transverse fissures in rails to be caused by gagging; types caused by local application of gag to head and base of rail are described.[4]

Interesting tests are being developed by the Bureau of Standards and others for detecting flaws in steel by electricity. In testing a rail, for example, a magnetic field is induced in the metal by magnets which can be moved along the length of the rail. Differences in homogeneity of the

[1] *Amer. Soc. Test. Mat.*, June, 1915.
[2] *Bull. Amer. Inst. Min. Eng.*, Mar., 1915.
[3] *Amer. Ry. Eng. Assn.*, Mar., 1915; Sept., 1915.
[4] *Ry. Age Gaz.*, Nov. 26, 1915.

metal cause changes in the intensity of the induced magnetism, which can be detected by suitable recording devices.

Radiography has been applied to detect hidden flaws in metals.[1] Valuable information was obtained in detection of blow-holes, slag inclusions, porous spots and defects of similar nature, which could not be found in any other way than by cutting the metal. The method is practicable for a thickness of metal up to ½ in.

J. S. Unger[2] contends that high sulphur, at any rate in an amount not exceeding 0.10 per cent., need not be the cause of poor hot working and physical qualities in the steel. Numerous heats were made of varying sulphur- and carbon-content, and these were rolled into various structural forms, and forged into crankshafts, chains, and the like, without developing any more troubles than customary steels of 0.05 per cent. or less of sulphur.

The manufacture of special steels has been seriously affected by a lack of the alloying metals, and at a time when the demand has been excessive. Ferro-silicon has been scarce, and prices advanced 20 per cent. Ferro-chrome has been imported largely from France and Scandanavian countries, and supplies have been practically cut off, with a resulting advance in price of 50 per cent. The extreme shortage of tungsten, a large proportion of which has been imported, has led to extensive exploitation of deposits in the West, but the great demand for the metal in time of excessive demand for tool and magnet steels caused the price to soar from 75 cts. to upward of \$6 to \$8 per lb. The use of ferro-titanium has increased considerably, especially for deoxidation of castings, since the price of aluminium has been almost prohibitive. Vanadium has not been directly influenced by the war, but the use of aluminium in its production has caused the price to rise sharply of late.

Silicon steel is to be employed in the construction of a long-span bridge across the lower Ohio River.[3] All the main members except eye-beams will be of the above steel, with a minimum of 0.25 per cent. silicon, ultimate strength to be 80,000 to 90,000 lb. per sq. in., and yield point 45,000.

Remarkable magnetic qualities were obtained with silicon-iron alloys made from electrolytically deposited iron fused with silicon in an electric vacuum furnace.[4] The best results were obtained with a silicon-content 0.15 and 3.4 per cent., after annealing at 1100° C. The hysteresis losses observed were one-eighth and one-third respectively, of those noted for commercial silicon steel. The permeabilities were remarkably high.

[1] Davey, *Trans. Amér. Electrochem. Soc.*, **28**, 407 (1915).
[2] *Soc. Auto. Engrs.*, Jan. 6, 1916.
[3] *Eng. Mag.*, vol. **69**, 1915.
[4] *Amer. Inst. Elec. Eng.*, Oct., 1915.

Commercial utility is largely a question of cost as compared with the advantages accruing.

The much mooted question of the "why" of hardening of steel has continued to be the subject of animated discussion, particularly in England. All have their value in adding something to our sum total of knowledge, but nothing has yet been developed which has been incontrovertible and which has satisfied our craving for a scientifically acceptable explanation of the many phenomena involved.

A. Sauveur summarizes the development and status of present-day theories of hardening of steel.[1] They are based upon the following conceptions: (1) Existence of a hard allotropic variety of iron; (2) existence of solid solution involving the occurrence of so-called "hardening" carbon; and (3) existence of strains in quenched steel causing or not an amorphous condition of the iron.

Interesting contributions to the subject are given by several investigators. A general discussion of the problem was held by the Faraday Society.[2]

An important discussion of the factors involved in hardening tool steel is given by J. A. Matthews and W. J. Stagg. The paper deals with time of heating and cooling, mass of section, and other practical considerations.

The effect of quenching mediums on steel is reported by H. V. Wille.[4] Physical properties of treated steels, internal stresses induced by quenching, and other factors are considered.

Much data from large scale exposure tests is being gathered which tend to show the marked influence of small amounts of copper (0.25 per cent. or less) in augmenting the resistance of steel sheets to weathering action.[5] The detrimental effect of sulphur is shown, and the pronounced effect of copper additions in neutralizing this harmful influence. The matter is still the subject of controversy by manufacturing interests, and other influences, particularly the presence or absence of gases in the metal, are claimed to be the fundamental cause of poor or good quality so far as corrosion resistance is concerned.

The corrosion of iron and steel was the subject of a general discussion before the Faraday Society.[6]

The Johnson process of oxygenation of cast iron has made progress. In roll foundries much iron of a quality equal to the best charcoal iron has been made by partially blowing ordinary coke pig iron. The cast-

[1] *Inter. Eng. Cong.*, 1915.
[2] *Trans. Faraday Soc.*, vol. **10**, 1915.
[3] *Amer. Soc. Mech. Eng.*, vol. **37**, 1915.
[4] *Amer. Soc. Test. Mat.*, 1915.
[6] *Amer. Iron & Steel Inst.*, Mar., 1915.
[5] *Trans. Faraday Soc.*, Dec., 1915.

ings are better than ordinary iron because of the oxygen introduction and low sulphur.

B. Stoughton is successfully operating foundry cupolas with crude oil partially replacing coke as fuel. The aim was primarily to substitute the oil for some of the more expensive coke where relative prices of the fuels warranted, but a secondary result of even greater importance was obtained, in a gain of only about one-fifth of the sulphur usually resulting from re-melting with coke as fuel.

A most important paper dealing with the factors influencing chill in cast iron, was given by G. M. Thrasher.[1] Mere regulation of silicon is insufficient to produce the desired degree of chill, and variations in total carbon have a strong influence. A chart is given showing lines of equal natural chill in terms of silicon and carbon percentages, and their application in making malleable castings.

[1] *Amer. Inst. Min. Eng.*, Feb., 1916.

LEAD

By H. B. Coho

The lead industry in 1915 made good gains in output, both in mining and smelting. The lead-content of ore mined in the United States showed a considerable increase, and with the higher prices prevailing the percentage of increase in value of the 1915 output was even greater as compared with other years, than the increase in production.

During 1915 construction was begun on one lead smelter and plans were completed for another, both to treat ore from the Coeur d'Alene district of Idaho. The Hercules Mining Co. purchased the copper smelter at Northport, Wash., and began the construction of two lead furnaces. This company is affiliated with the Pennsylvania Smelting Co. of Pittsburgh, Pa. The Bunker Hill & Sullivan Co. of the Coeur d'Alene district also completed plans for a smelter, but the site is yet in abeyance. The National refinery of the American Smelting & Refining Co., at Chicago, was dismantled, and the Balbach Smelting & Refining Co. abandoned its older lead plant at Newark, N. J.

The following statistics have been compiled by C. E. Siebenthal from reports to the United States Geological Survey. The statistics of imports, exports, and lead remaining in warehouse have been taken from the records of the Bureau of Foreign and Domestic Commerce.

The production of refined lead, desilverized and soft, from domestic and foreign ores in 1915 was 550,055 short tons, worth at the average New York price $51,705,000, compared with 542,122 tons, worth $42,-285,500, in 1914, and with 462,460 tons in 1913. The figures for 1915 do not include an output of 23,224 tons of antimonial lead against 16,667 tons in 1914 and 14,667 tons in 1913. Of the total production, desilverized lead of domestic origin, exclusive of desilverized soft lead, was 301,564 tons, against 311,069 tons in 1914 and 250,578 tons in 1913; and desilverized lead of foriegn origin 43,029 tons, compared with 29,328 tons in 1914 and 50,582 tons in 1913. The production of soft lead, mainly from Mississippi Valley ores, was 205,462 tons, compared with 201,725 tons in 1914 and 161,300 tons in 1913. The total production of lead, desilverized and soft, from domestic ores, was thus 507,026 tons, compared with 512,794 tons in 1914.

METALLURGICAL PRODUCTION OF LEAD IN THE UNITED STATES (*a*)
(Refinery statistics. In tons of 2000 lb.)

Year.	Domestic Origin.					Foreign Origin.		Grand Total.
	Desilverized.	Antimonial.	S. E. Mo.	S. W. Mo.	Total.	Desilverized.	Antimonial.	
1910........	217,490	9,098	145,387	20,729	392,704	90,473	4,892	488,069
1911........	211,041	8,916	155,008	25,993	400,958	89,487	4,929	495,374
1912........	236,207	9,239	145,336	19,224	410,006	82,715	5,003	497,724
1913........	261,616	16,345	133,203	22,312	433,476	54,774	2,300	490,550
1914........	318,697	17,177	177,413	25,448	538,735	28,475	1,119	568,329
1915........	317,463	24,370	197,427	26,096	565,356	47,405	2,492	615,253

(*a*) From *Eng. Min. Jour.*

Imports and Exports

The imports of lead were 9092 short tons of lead in ore, 41,993 tons of lead in base bullion and 410 tons of refined and old lead, a total of 51,495 tons, valued at $3,431,829 compared with 28,338 tons in 1914. Of the imports in 1915 46,779 tons came from Mexico, against 23,133 tons in 1914. These imports from Mexico are to be compared with an average of over 100,000 tons before the civil strife in that country. The remaining imports of lead came mostly from Chile.

IMPORTS OF LEAD, IN ORE, BASE BULLION, AND REFINED, BY COUNTRIES, 1909–1915, IN POUNDS

Country.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
United Kingdom.	191,243	1,874,750	401,686	279,546	404,594	245,548	185,236
Germany.........	2,821,967	421,377	56,286	494,237	262,132	4,529,919	....
Other European countries.	1,385,616	418,669	111,189	55,356	143,293	123,085	32,537
British North America .	4,133,755	206,979	270,947	319,497	338.569	384,007	2,303,170
Mexico.	215,203,714	203,290,307	172,633,479	159,455,664	95,693,439	46,282,207	94,247,384
South America...	1,942,847	6,598,263	4,778,221	3,207,936	8,766,327	2,417,744	5,420,567
Other countries..	2,683,950	4,394,421	1,651,544	3,309,365	8,685,612	2,694,293	802,516
Total imports.	228,363,092	217,204,766	179,903,352	167,121,601	114,293,966	56,676,803	102,991,410

IMPORTS OF LEAD, BY CLASSES, 1907–1912, IN POUNDS

Year.	Lead in Ore (Lead Content).	Base Bullion.		Pigs, Bars, Sheets, and Old.	Total Lead Content.[1]
		Gross Weight.	Lead Content.[1]		
1908...............	64,708,204	153,921,829	150,560,176	5,518,621	220,787,001
1909...............	71,357,868	149,852,559	146,579,779	7,152,665	225,090,312
1910...............	94,751,054	118,061,415	115,483,542	6,970,170	217,204,766
1911...............	35,686,180	141,481,852	138,952,372	5,264,800	179,903,352
1912...............	19,577,499	152,420,624	146,999,168	544,925	167,121,592
1913...............	19,883,313	96,908,170	94,327,654	82,999	114,293,966
1914...............	23,649,637	33,444,503	32,730,320	296,846	56,676,803
1915...............	18,185,140	86,247,995	83,986,988	819,282	102,991,410

[1] Lead content of bullion for 1907–1909 estimated on the basis of average lead content of imports of base bullion in 1910.

The exports of lead of foreign origin smelted or refined in the United

States show an increase, being 42,428 tons, against 31,051 tons in 1914 and 54,301 tons in 1913. For the last 2 years, on the other hand, notable quantities of domestic lead have been exported to Europe, and the total for 1915 was 87,092 short tons, valued at $7,796,998, compared to 58,722 tons, vaued at $4,501,674, in 1914.

Lead Available for Consumption

The amount of lead available for consumption during 1915 may be estimated by adding to the stock of foreign lead (domestic stocks are not known) in bonded warehouses at the beginning of the year (7668 short tons) the imports (51,496 tons), the additions by liquidation (2250 tons), and the domestic production (507,026 tons), making an apparent supply of 568,440 tons. From this are to be subtracted the exports of foreign lead (about 42,428 tons), the exports of domestic lead (87,092 tons), and the stock in bonded warehouses at the close of the year (12,169 tons), leaving as available for consumption 426,751 tons compared with 449,052 tons in 1914.

PRIMARY REFINED LEAD AVAILABLE FOR CONSUMPTION IN THE UNITED STATES
(Short tons)

	1910.	1911.	1912.	1913.	1914.	1915.
Supply:						
Stock in bonded warehouses Jan. 1	17,405	35,972	4,481	10,492	5,310	7,668
Imports—						
For consumption	15,359	13,281	14,146	11,980	7,386	9,680
For warehouse	93,249	76,671	69,414	45,165	20,952	41,816
Increase by liquidation	....	....	....	....	....	2,250
Production from domestic ores	375,402	391,995	392,517	411,878	512,794	507,026
Total supply	501,415	517,919	480,558	479,515	546,442	568,440
Withdrawn:						
Exports of foreign lead—						
From warehouse	69,786	101,227	64,906	44,544	21,545	38,445
In manufactures, with benefit of drawback	8,800	12,080	11,320	9,757	9,399	3,983
Exports of domestic lead	....	....	....	....	58,722	87,092
Decrease by liquidation	7,661	14,812	5,692	419	56	....
Stock in bonded warehouses Dec. 31	35,972	4,481	10,492	5,310	7,668	12,169
Total withdrawn	122,219	132,600	92,410	60,030	97,390	141,689
Available for consumption	379,196	385,319	388,148	419,485	449,052	426,751

[1] U. S. Geol. Surv.

The Lead Market in 1915

Lead began the year at New York with a price of 3.8 cts. per lb., nearly the minimum price of the year, and remained practically stationary until the middle of February. A gradual rise brought the price to 4.2 cts. in April, and it remained there until the later part of May. A rapid rise next followed, and lead reached the maximum for the year at 7.56 cts. on June 14. A sharp decline, followed by partial recovery and then by a more general decline, brought the price to 4.4 cts. in the later part of August. After a slight recovery and another decline to 4.45 cts. in September, the price gradually rose and closed the year at about 5.4 cts. The average New York price for the year was 4.7 cts. per lb., compared with 3.9 cts. in 1914 and 4.4 cts. in 1913.

The London price of lead started at £19 a long ton (4.1 cts. per lb.) and rose until the later part of March, when it reached £23 2s. 6d. a long ton (5 cts. per lb). From this point the price fell to £20 1s. 3d. a long ton (4.3 cts. per lb.), after which there was a sharp ascent to £28 2s. 6d. (6.1 cts. per lb.) at the middle of June. After several ups and downs the price dropped to £20 6s. 3d. (4.4 cts. per lb.) by the middle of August, and then a gradual rise carried it to £29 5s. a long ton (6.3 cts. per lb.), and it closed the year at about that figure. The London market was fairly parallel to the New York market and, except for the period of high prices in the United States during July and August, was uniformly higher than the American market.

AVERAGE MONTHLY PRICE OF LEAD PER POUND IN NEW YORK

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
1901...	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.35	4.15	4.33
1902...	4.00	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.075	4.069
1903...	4.075	4.075	4.442	4.567	4.325	4.210	4.075	4.075	4.243	4.375	4.218	4.162	4.237
1904...	4.347	4.375	4.475	4.475	4.423	4.196	4.192	4.111	4.200	4.200	4.200	4.600	4.309
1905...	4.552	4.450	4.470	4.500	4.500	4.500	4.524	4.665	4.850	4.850	5.200	5.422	4.707
1906...	5.600	5.464	5.350	5.404	5.685	5.750	5.750	5.750	5.750	5.750	5.750	5.900	5.657
1907...	6.000	6.000	6.000	6.000	6.000	5.760	5.288	5.250	4.813	4.750	4.376	3.658	5.325
1908...	3.691	3.725	3.838	3.993	4.253	4.466	4.477	4.580	4.515	4.351	4.330	4.213	4.200
1909...	4.175	4.018	3.986	4.168	4.287	4.350	4.321	4.363	4.342	4.341	4.370	4.560	4.273
1910(*a*	4.700	4.613	4.459	4.376	4.315	4.343	4.404	4.400	4.400	4.400	4.442	4.500	4.446
1911(*a*	4.483	4.440	4.394	4.412	4.373	4.435	4.499	4.500	4.485	4.265	4.298	4.450	4.420
1912(*a*	4.435	4.026	4.073	4.200	4.194	4.392	4.720	4.569	5.048	5.071	4.615	4.303	4.471
1913(*a*	4.321	4.325	4.327	4.381	4.342	4.325	4.353	4.624	4.698	4.402	4.293	4.047	4.370
1914(*a*	4.111	4.048	3.970	3.810	3.900	3.900	3.891	3.875	3.828	3.528	3.683	3.800	3.862
1915(*a*	3.729	3.827	4.053	4.221	4.274	5.932	5.659	4.656	4.610	4.600	5.155	5.355	4.628

(*a*) From *Eng. Min. Jour.*

AVERAGE MONTHLY PRICE OF LEAD PER 2240 LB. AT LONDON (*a*)
(In pounds sterling)

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1901....	15.925	14.667	13.379	12.421	12.275	12.342	12.150	11.692	11.954	11.600	11.267	10.533	12.521
1902....	10.567	11.617	11.508	11.596	11.600	11.271	11.233	11.121	10.892	10.746	10.717	10.754	11.262
1903....	11.304	11.708	13.225	12.404	11.800	11.437	11.383	11.146	11.167	11.108	11.108	11.179	11.579
1904....	11.558	11.592	12.037	12.254	11.754	11.521	11.667	11.737	11.787	12.187	12.892	12.775	11.983
1905....	12.875	12.462	12.296	12.658	12.762	13.000	13.608	13.958	13.950	14.679	15.337	17.050	13.719
1906....	16.850	16.031	15.922	15.959	16.725	16.813	16.525	17.109	18.266	19.350	19.281	19.609	17.370
1907....	19.828	19.531	19.703	19.975	19.688	20.188	20.350	19.063	19.775	18.531	17.281	14.500	19.034
1908....	14.469	14.250	13.975	13.469	12.938	12.600	13.000	13.375	13.125	13.375	13.538	13.156	13.439
1909....	13.113	13.313	13.438	13.297	13.225	13.031	12.563	12.475	12.781	13.175	13.047	13.125	13.042
1910....	13.650	13.328	13.063	12.641	12.550	12.688	12.531	12.513	12.582	13.091	13.217	13.197	12.920
1911....	13.009	13.043	13.122	12.889	12.984	13.260	13.530	14.260	14.744	15.332	15.821	15.648	13.970
1912....	15.597	15.738	15.997	16.331	16.509	17.588	18.544	19.655	22.292	20.630	18.193	18.069	17.929
1913....	17.114	16.550	15.977	17.597	18.923	20.226	20.038	20.406	20.648	20.302	19.934	17.798	18.743
1914....	19.665	19.606	19.651	18.225	18.503	19.411	19.051	(*b*)	(*b*)	(*b*)	18.500	19.097	......
1915....	18.606	19.122	21.883	21.094	20.347	25.170	24.611	21.946	23.151	23.994	26.278	28.807	22.917

(*a*) The statistics for 1897–1905 are from the report of the Metallgesellschaft, Frankfurt-am-Main. Those for subsequent years are from the *Eng. Min. Jour.* (*b*) London exchange closed.

White Lead and Oxides in 1915[1]

Prices of lead pigments fluctuated more violently and reached a higher level during the last 6 months than at any other period since commercial conditions became normal after the inflation during and following the Civil War. The indirect influence of the European war upon pig lead, and speculative operations in that commodity, caused a rapid advance during the latter part of May and resulted in a rise of over 2½ cts. per lb. before the middle of June. As a consequence, white lead in oil, which had remained at 6¾ cts. from November, 1913, to June 1, 1915, was advanced on the latter date to 7 cts., with further advances of ¼ ct. on the fourth, ½ ct. on the seventh and 1 ct. on the ninth, making the price on that date 8¾ cts., or 2 cts. per lb. above the figures that had ruled for more than 18 months prior to June 1.

A break in pig lead was promptly followed on June 22 by a reduction of 1 ct. in the price of white lead in oil, and subsequent reductions brought the price back on Aug. 19 to the level of June 1, 6¾ cts., thus covering an advance of 2 cts. per lb. and an equal decline in 2½ months. Since the last-named date there have been two advances, following pig lead, and at the close the minimum price is 7¼ cts. The frequent changes have had a more or less distributing effect upon business, which was restricted by the extreme advance, but the sales for the year have been in excess of 1914 and reflect a heavier domestic consumption, as well as a considerable export business with the Latin-American markets.

Dry white lead has not followed closely the fluctuations recorded for lead in oil, but from an opening figure of 5 cts., there was a gradual advance to 5½ cts., during the first half of the year and in June corroders made a 7¾-cts. price as a safeguard against the uncertain future of pig lead. With the subsequent decline in the latter, dry lead settled back to a 6 ct. basis, but subsequently advanced to 6¼ cts., which is the quotation at the close, but with guarded selling on contracts running into 1916.

Oxides were weak at the opening of the year and only began to stiffen up in April, when the pig-lead market showed a very positive advancing tendency. Red lead at that time advanced to 6 cts. and 6¼ cts. from an opening of 5½ cts. to 5¾ cts. and in the June rise went to 8¼ cts., after which there was a gradual decline to 6½ cts. in September, with a subsequent gain of ¼ ct. in November and again in December, making the minimum price at the close 7 cts. Litharge has followed a similar course, opening at 5 cts. and advancing in June to 8¼ cts., but later reacted and in September was down to 6 cts., with subsequent advances to 6½ cts. at the close.

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

A. S. & R. CO. PRICES FOR PIG LEAD
(New York delivery in cents per pound)

Opening	3.80	June 4	5.20	Aug. 10	4.50
Jan. 12	3.70	June 7	5.50	Aug. 25	4.60
Jan. 28	3.80	June 8	5.75	Aug. 26	4.70
Feb. 15	3.85	June 10	6.25	Aug. 27	4.90
Mar. 1	3.90	June 11	6.50	Sept. 9	4.70
Mar. 5	3.95	June 12	7.00	Sept. 14	4.50
Mar. 17	4.10	June 17	6.25	Oct. 22	4.75
Mar. 24	4.15	June 18	6.00	Oct. 29	4.90
Apr. 1	4.20	June 19	5.75	Nov. 4	5.00
May 21	4.30	June 21	5.00	Nov. 10	5.15
May 27	4.40	June 26	5.75	Nov. 15	5.25
May 28	4.50	July 30	5.50	Dec. 14	5.40
May 31	4.75	Aug. 2	5.25	Dec. 31	5.50
June 1	4.90	Aug. 7	5.00		
June 3	5.00	Aug. 9	4.75		

Very little business was done in any of these products at the extreme figures, which were established more as a precautionary measure while the course of pig lead was so uncertain. Even now the market for all lead pigments is sensitive to fluctuations in the metal, and at no time since the June advance have manufacturers felt justified in guaranteeing prices for any long period or entering into contracts that were not fairly covered by the material they had in sight.

While the export outlet for all lead pigments reached increased proportions during the year, manufacturers still regard this business as one of doubtful permanency, although there are gratifying evidences that on an even price basis a large share of it could be retained against any foreign competition.

The cost of linseed oil has had a strengthening effect on the price of white lead in oil throughout the year, having advanced steadily from an opening figure of 48 cts. per gal. to 65 cts. in May, with fluctuations between that figure and 60 cts. since, about 62 cts. being the closing figure.

PRODUCTION OF LEAD PIGMENTS IN THE UNITED STATES

Year.	Red Lead.		White Lead. (*a*)		Litharge.		Orange Mineral.	
	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.	Short Tons.	Value.
1899...	10,199	$1,070,895	103,466	$10,812,197	10,020	$1,032,060	928	$ 139,200
1900...	10,098	1,050,192	96,408	9,910,742	10,462	1,067,124	825	100,650
1901...	13,103	1,448,550	100,787	11,252,653	9,460	979,586	1,087	224,667
1902...	11,669	1,262,712	114,658	11,978,172	12,755	1,299,443	867	138,349
1903...	12,300	1,385,900	112,700	12,228,024	12,400	1,326,800	1,000	168,000
1904...	13,938	1,672,569	126,336	13,896,913	12,487	1,248,691	1,125	168,681
1905...	16,269	1,919,767	122,398	12,068,443	12,643	1,422,616	1,000	120,000
1906...	13,693	1,874,448	123,640	15,234,990	13,816	1,890,050	2,927	421,488
1907...	13,370	1,778,717	111,409	12,254,297	14,769	1,624,553	815	123,917
1908...	11,358	1,156,282	116,628	10,515,315	12,254	1,231,206	393	43,157
1909...	15,800	1,438,197	131,643	12,652,638	13,391	1,266,903	530	68,003
1910 (*b*)	16,116	1,482,672	134,276	13,024,762	13,659	1,283,940	541	70,335
1911 (*b*)	19,594	2,345,520	132,612	17,393,241	25,190	2,733,196	766	119,370
1912 (*b*)	21,120	2,571,702	146,833	18,683,461	29,111	3,194,194	545	88,240
1913 (*b*)	17,635	2,127,976	142,626	18,112,219	23,093	2,524,707	434	71,625
1914	18,697	2,151,054	159,474	19,943,239	27,345	2,856,092	426	70,019

(*a*) The output of "sublimed white lead," a mixed sulphate and oxide of lead, is not included n 1904–1910. (*b*) U. S. Geol. Surv.

IMPORTS OF LEAD PIGMENTS INTO THE UNITED STATES

Year.	Red Lead.		White Lead.		Litharge.		Orange Mineral.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
1900.....	549,551	$25,532	456,872	$28,336	77,314	$2,852	1,068,793	$61,885
1901.....	485,466	19,369	384,671	21,226	49,306	1,873	977,644	52,409
1902.....	1,075,839	37,833	506,423	25,320	88,115	2,908	997,494	49,060
1903.....	1,152,715	40,846	453,284	24,595	42,756	1,464	756,742	36,407
1904.....	836,077	30,115	587,383	33,788	44,541	1,500	766,469	37,178
1905.....	704,402	26,553	597,510	34,722	117,759	4,139	628,003	31,106
1906.....	1,093,619	50,741	647,636	41,233	87,230	3,737	770,342	42,519
1907.....	679,171	35,959	584,309	37,482	90,475	4,386	615,015	37,799
1908.....	645,073	28,155	540,311	30,451	96,184	3,327	485,407	26,645
1909.....	760,179	30,428	694,599	39,963	90,655	3,740	496,231	27,562
1910.....	822,289	32,750	686,052	38,919	48,693	2,252	600,461	32,199
1911.....	1,163,533	46,170	741,071	46,213	24,662	1,196	504,734	28,515
1912.....	757,908	33,854	687,705	46,494	32,443	1,550	334,551	20,914
1913.....	99,832	4,903	672,109	45,266	34,023	1,750	330,525	22,205
1914.....	13,554	2,907	596,567	40,213	33,651	1,805	240,388	16,388
1915.....	1,968	142	239,187	24,608	20,650	1,422	171,572	14,061

PRIMARY LEAD SMELTED OR REFINED IN THE UNITED STATES
(Short tons) (Apportioned according to source of ore)

	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Domestic Ore:									
Alaska	....	3	69	75	51	45	6	....	358
Arizona	2,418	1,464	1,507	948	3,428	3,891	4,901	5,602	6,953
Arkansas	15	....	14	....	15	....	....	52	51
California	938	515	977	1,207	615	811	3,294	3,698	5,606
Colorado	52,552	28,729	30,865	38,542	30,442	37,039	42,840	41,198	32,352
Idaho	123,292	98,464	103,747	109,951	117,335	127,780	137,802	177,827	160,680
Illinois	498	362	273	263	308	513	619	427	910
Iowa	225	110	15	....	....	....	....	34	....
Kansas	1,798	2,293	2,763	1,308	2,522	1,937	1,504	1,043	1,320
Kentucky	75	....	....	50	....	91	16	16	95
Missouri	122,856	122,451	141,105	161,659	182,203	162,610	152,430	194,275	195,634
Montana	2,145	2,320	1,451	1,943	2,484	2,517	3,256	4,386	4,853
Nevada	3,480	3,796	4,792	2,246	1,082	5,699	6,142	5,996	7,664
New Mexico	2,047	586	1,350	1,890	1,371	2,511	1,821	741	2,157
North Carolina	....	....	....	2	35	34	10	....	....
Oklahoma	404	1,409	2,268	1,805	1,925	2,500	3,214	3,916	4,346
Oregon	5	7	7	....	11	21	37	17	11
South Dakota	....	13	....	8	33	12	7	2	5
Tennessee	16	....	....	....	....	....	....	....	8
Texas	12	42	44	36	57	30	108	89	111
Utah	55,540	42,455	66,648	60,605	54,933	60,664	71,069	88,976	106,105
Virginia	83	13	....	87	400	85	878	143	457
Washington	341	391	120	339	612	53	9	2	11
Wisconsin	3,573	4,013	3,252	3,909	3,966	3,301	2,639	1,818	2,632
Undistributed	896	36	317	101	48	120	63	99	131
Zinc residues	1,890	1 290	1,735	2,237	1,987	3,131	3,765	4,125	4,567
Total from domestic ore.	375,099	310,762	363,319	389,211	405,863	415,395	436,430	534,982	537,012
Foreign Ore:									
Africa	288	....	3,150	3,310	582	1,774	5,976	2,942	....
Canada	2,607	162	66	25	122	29	16	2	1,174
Central America	23	12	20	3	28	....	....	....	1
Mexico	20,204	10,145	16,944	11,704	7,333	7,407	4,512	2,386	5,437
South America	919	1,186	1,536	2,996	2,677	2,332	2,617	1,821	2,829
Other foreign	....	4	38	27	22	30	102	488	140
Foreign Base Bullion:									
Canada	2,716	179	1,500	....	....	....	....	....	....
Mexico	34,251	73,210	70,816	76,805	84,220	76,805	37,359	21,689	33,176
Total from foreign ore and base bullion.	61,008	84,898	94,070	94,870	94,984	88,377	50,582	29,328	43,029
Grand total, derived from all sources.	436,107	395,660	457,389	484,081	500,847	503,772	487,012	563,810	580,044

Lead in the United States

Alaska.—The lead production in Alaska in 1915 amounted to 358 tons, the largest production recorded from the territory.

Arizona.—The lead production in Arizona in 1915 amounted to 6953 tons as compared with 5601 tons in 1914. Most of this production came from the Copper Queen and the Shattuck properties near Bisbee and the Tennessee mine of the U. S. Smelting, Refining and Mining Co., near Kingman.

California.—The 1915 production amounted to 5606 tons as compared with 3698 tons in 1914. The larger proportion of this production came from the Cerro Gordo Co., in Inyo County.

Colorado.—The lead production in Colorado decreased considerably in 1915 amounting to only 32,352 tons as compared with 41,198 tons in 1914 and 42,840 tons in 1913. The accompanying table gives the distribution of the production from the principal producing districts for previous years.

LEAD PRODUCTION OF COLORADO (*a*)
(In tons of 2000 lb.)

County.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914. (*b*)
Clear Creek..	1,439	1,832	1,205	1,495	1,228	1,956	2,423	2,160	1,218
Hinsdale.....	442	470	82	50	124	60	611	410	3
Lake........	23,918	17,032	7,169	7,061	6,364	8,119	12,368	14,000	13,392
Mineral......	7,443	6,490	4,119	4,526	4,066	3,501	2,634	1,780	702
Ouray.......	2,861	1,803	1,516	1,354	2,021	2,002	1,531	1,200	1,060
Pitkin.......	8,781	6,957	3,713	6,315	6,704	5,090	4,195	8,390	11,616
San Juan....	2,070	6,213	5,133	4,921	5,444	3,140	4,452 }	14,900	2,600
Others.......	6,038	5,696	5,918	6,638	3,332	8,891	8,475 }		....
Total......	52,992	46,493	28,855	32,360	29,283	32,759	36,689	42,840	41,198

(*a*) As reported by the State Commissioner of Mines.
(*b*) U. S. Geol. Surv.

Idaho.—Idaho ranks second among the States producing lead, the production for 1915 amounting to 160,680 tons as compared with 177,827 tons in 1914. The decrease in production from the previous year is largely due to smelter-market troubles which kept two of the largest producers out of commission for 3 months of the year, one of them the Hercules, one of the largest producers of lead-silver ore in the district. The Bunker Hill and Sullivan Co. made the record output of its history and in connection with the adjacent operations of the Stewart Last Chance, Ontario and Caledonia mines gave the Kellogg-Wardner division of the Coeur d'Alene field a complete output of about one-half of the State's production, a remarkable result considering that a large proportion of the tonnage treated came from the horizon between 3000 or 4000 ft. deep in the dip of the Bunker Hill vein.

The Morning mine at Mullan owned by the Federal Co. continues to manifest splendid prospects of permanence and the biggest developed ore resources of its history.

The deep levels of the Hecla mine have shown a remarkable expansion and continuation of the clean lead sulphide mineral for which this deposit has always been noted. The deepest level of the Hercules mine now operated through a 3-mile tunnel continues to show persistent expansion in length of its ore channel with the addition of new shoots of mineral of big productive capacity.

The Idaho Continental mine in Boundary County has been developed 600 ft. deep by three adit tunnels. It was equipped with a 200-ton mill which began operations during the summer but after producing 2000 tons of 50 per cent. lead concentrates the plant was destroyed by fire. It has since been re-built.

In the Gilmore district the Pittsburgh-Idaho and the Latest Out mines shipped about 10,000,000 lb. of lead-contents in crude ore. In the Dome district of Fremont County, the Wilbert mine produced about 600 tons of 50 per cent. concentrates and crude ore a month during the greater part of the year. In the Wood River district several new strikes were recorded among the old lead-ore deposits, particularly at the Lipman, Carboniferous, Black Barb and Silver Fortune mines.[1]

Illinois.—The lead production of Illinois more than doubled in 1915 amounting to 910 tons as compared with 427 tons in 1914.

The shipments of silver-bearing galena concentrates from the southern Illinois fluorspar region amounted to 641 tons, 333 tons more than in 1914. The lead concentrates yielded an average recovery of 6.03 oz. of silver per ton, or 3864 oz. which was 1752 oz. more than the production in 1914.

The production of galena concentrates by mines in northern Illinois declined slightly—from 646 tons in 1914 to 641 tons in 1915. The recoverable lead-content of galena concentrates from Illinois in 1915 amounted to 954 tons, valued at $89,676, compared with 717 tons, valued at $55,926, in 1914.

Kansas.—The lead production in Kansas increased from 1043 tons in 1914 to 1320 tons in 1915. The quantity of galena concentrate marketed in 1915 was 1618 tons valued at $85,415 as compared with 1808 tons valued at $79,976 in 1914.

Missouri.—Missouri still continues to lead in the lead production with an output of 195,634 tons in 1915 as compared with 194,275 tons in 1914. The total quantity of lead concentrates purchased was 312,352 tons, 32,693 more than in 1914. Mines operated in the disseminated district in

[1] Robert N. Bell, *Eng. Min. Jour.*, Jan. 22, 1916.

southeastern Missouri produced 278,104 tons of concentrates containing an average of 66.5 per cent. lead. The Joplin region reported the sale of 34,248 tons of galena concentrates and 215 tons of lead carbonate concentrates, about 3600 tons more than in 1914.[1]

Southeastern Lead District.[2]—The production last year is especially noteworthy, as there was a marked curtailment during the first part of the year, when the lead market was very low, or less than 4 cts. per lb. in St. Louis. With the improvement in prices that took place in April, the district tuned up to full speed and finished the year under full pressure and great activity.

St. Francois County produced nearly 95 per cent. of the output of southeastern Missouri in 1915 from the mines of the St. Joe, Federal, National, Desloge and Baker lead companies in the Bonne Terre, Big River and Flat River districts. These mines all produce from the deep, low-grade, large disseminated deposits that occur at depths of 100 to 600 ft. in the "Bonne Terre" limestone. The shallow diggings in Washington County, which adjoins St. Francois on the west, did not produce much lead in 1915, nor did Franklin County to the north. Jefferson County, which is immediately north of St. Francois County, has a few shallow diggings that contain both lead and zinc, and under the stimulus of the high zinc market in 1915 produced a limited amount of zinc carbonate and galena.

The labor situation has been very satisfactory throughout the district during the past year, as there have been plenty of men and no strikes. When the price of lead took the sharp upward turn, there was a clamor for higher wages that resulted in giving the men a bonus of 25 cts. per day, which is still continued, although the price of lead has considerably receded.

The St. Joseph Lead Co. had a most successful year in 1915 under its new régime and made by far the largest output in its long, highly successful career. This was mainly due, however, to the absorption of the Doe Run Lead Co., with which it has always been closely affiliated and which was taken over by the parent company in 1914 on a stock basis. Ten shafts were operated that furnished the ore, via the Mississippi River & Bonne Terre R. R., which it owns, for the old 1500-ton mill at Bonne Terre, for the 1500-ton mill at Owl Creek (on Big River) and for the 4000-ton Doe Run mill at Rivermines, in the Flat River district. The original mine at Bonne Terre, which is nearly 50 years old and was the first disseminated mine in the district, is still a large and active producer. The smelter at Herculaneum, on the Mississippi River, was

[1] U. S. Geol. Surv.
[2] H. A. Wheeler, *Eng. Min. Jour.*, Jan. 8, 1916.

further improved and can now treat 12,000 tons of concentrates per month with a high efficiency as regards recovery. The Peugnet tract at Bonne Terre has been optioned at $1000 per acre and is now being drilled.

The Desloge Lead Co. pursued its usual policy of quietly pushing production to its top notch and maintaining its plant in excellent condition. It operated three shafts that supplied its 1600-ton mill on Big River at the town of Desloge. While most of the concentrates were shipped to a custom smelter in the East St. Louis district, its small plant of Flintshire or air furnaces at Desloge were kept in operation, as usual —a type of smelting this company has tenaciously adhered to, at least on a moderate scale. This company operates its own railroad between the scattered shafts and mill, which connects with the Mississippi River & Bonne Terre R. R. at Desloge station.

The National Lead Co.'s mines are at St. Francois station, in the Flat River district, where it operates four shafts on a compact body of land that is equipped with an excellent 2000-ton mill. A central rockhouse situated near the mill is employed, to which all the ore is hauled from the scattered shafts by an electric trolley system, the only one used in the district. All the ore is sampled and weighed before it is milled, and all of the mill products are sampled and assayed, thus giving complete information as to the actual work of the mill. The concentrates are shipped to the National Co.'s large smeltery at Collinsville, Ill., which also does custom work. The plants were run at full capacity during 1915 and turned out the largest output in their history. Options were taken on considerable St. Francois County land, which is now being drilled, and several tracts were purchased.

The Federal Lead Co. operated seven shafts in 1915 on its very extensive property in the Flat River district, from which the ore is hauled by its own railroad to a central rockhouse and 4000-ton mill on the land acquired from the old Central Lead Co. To appreciate the magnitude of its operations and to realize the difficulties of wasting such a heavy tonnage of resulting tailings, one has only to glance at the huge pile— or rather, young mountain—of tailings that has accumulated in the short life of this mill, which is the largest in the district. Although advantage was taken of a draw or gentle valley near the mill in which to dump the tailings from a high wire-rope tramway, this was soon outgrown, and now a rubber-belt conveyor set at a high angle is employed, to which "dummies," or extensions, are built as "Mount Federal" enlarges.

A new shaft, No. 12, was started last August that will be 460 ft. deep. It will be equipped with an electric hoist that will operate two 4½-ton skips. The concentrates are shipped to its large smelting plant at Alton.

Ill., which operates on the open-hearth and bag-house principle and also does custom work.

The Baker Lead Co., of Boston, succeeded the St. Francois Lead Co. in the ownership of the old Jake Day land on Big River. This is a tract that was peddled on the market for years, and almost every operator in the district has optioned it and turned it down, after more or less drilling. Boston interests finally took it over at about $1200 an acre on the strength of the previous drill records and sunk a shaft on the edge of Big River. It opened up one of the richest ore-bodies in St. Francois County, as mill runs for month after month on careful sampling assayed from 8 to 11 per cent. lead, as compared with a district of 3 to 6 per cent. The company has no mill, and the ore is being treated under a long-time contract by the National Lead Co., with whose mill it is connected by a spur of the Mississippi River & Bonne Terre R. R.

The Baker company recently acquired the "Jones Forty," a 40-acre tract between the old Central and Derby lands at Elvins, that is claimed to be very rich. At the reported price of $100,000, or $2500 per acre, this is the highest price yet paid for drilled but undeveloped farm lands, as the previous high was $1500 an acre. This property sold 15 years ago for $6000, or $150 an acre, when it was undrilled, although within a mile or so of good mines. A shaft has been started that will be 625 ft. deep, one of the deepest in the district.

The Mine la Motte Co., which operates the classic lead mine of America, had an active year and made the largest output in its history. Since the present company took hold 2 years ago, it has adopted several original ideas, the most important of which is to re-work the shallow diggings with steam shovels, in milling which there is quite a recovery of carbonate of lead. The disseminated ore-bodies are also being actively worked.

The Phœnix mine, formerly known as the Catherine, was re-opened last spring and is again being worked under lease by the Federal Lead Co. The adjoining Fleming tract is also being worked, as the Catherine ore-body extends into this land. The North American mine, at Fredericktown, is still closed down, and its costly smeltery is sadly suffering from disuse.

Montana.—Lead production in Montana has shown a steady increase for a number of years past. The output of 1915 was 4853 tons as compared with 4386 tons in 1914 and 3256 tons in 1913. Most of the production is from the lead zinc ores of the Silver Bow County with smaller amounts from Cascade and Lewis and Clark Counties.

Nevada.—The production of lead in Nevada increased considerably in 1915 the output amounting to 7664 tons as compared with 5996 tons in 1914, the principal sources being the lead-zinc mines in Lincoln and Clark Counties.

New Mexico.—Lead production in New Mexico is irregular. The amount varying considerably from year to year. The 1915 production amounted to 2157 tons as compared with 741 tons in 1914 and 1821 tons in 1913. Most of the production is obtained from lead ores, with smaller amounts from lead-zinc ores. The chief producing districts are Socorro County, Grant County and Luna County.

Oklahoma.—The lead production in Oklahoma in 1915 showed only a slight increase, the output amounting to 4346 tons as compared with 3196 tons in 1914. Development was active in the Oklahoma districts and the extended area of proved territory insures a larger future output under normal conditions. Many new mills were built or were under construction during 1915 but few were actually put in operation so that they contributed little to the 1915 output.

Tennessee.—Tennessee enters the list of lead producers this year with a production of 8 tons. On the Chatata property near Charlestown development has been under way on a lead-zinc property carrying sulphide ore. A test lot of galena was shipped but none of the zinc ore was marketed.

Utah.—Utah ranks third in lead production the 1915 output amounting to 106,105 tons as compared with 88,976 tons in 1914. The state has shown a considerable increase in production each year for a number of years.[1]

The Daly-Judge, Daly West, Silver King Coalition and Silver King Consolidated at Park City and the Utah Apex, Utah Metal and Tunnel Co. (including the Bingham-New Haven), the Utah Consolidated & the United States properties at Bingham were the principal shippers of lead-silver ores. The output at Park City was considerably larger than last year there being 18 shippers compared with 12 the previous year. Two new mills were built to treat tailings and produced lead and zinc concentrates, the Big Four Exploration Co. (250 tons) and the Broadwater mill (500 tons). The production from Alta and Big Cottonwood increased, there being 14 mines and prospects at work in the latter district. The Cardiff and South Hecla were the principal shippers. A few cars of silver-lead ore monthly were shipped by the Miller Hill, Pacific and others from American Fork. Stockton, Dry Cañon and Ophir showed increasing activity especially Dry Cañon, where numerous resources were at work. The Hidden Treasure, Mono Development, and Queen of the Hills in Dry Cañon, the Ophir Hill, Cliff and Lone Hill

[1] U. S. Geol. Surv.

Consolidated at Ophir, and the Bullion Coalition at Stockton made shipments. Tintic produced an increased tonnage.

The United States Smelting Co. at Midvale ran five furnaces on lead ore, increased its roasting capacity by the addition of two Dwight and Lloyd roasters and added to its bag-house. The wet concentrator was enlarged from 350 to 600 tons daily capacity and the Huff electrostatic plant from 60 to 100 tons. The American Smelting & Refining Co., at Murray had five furnaces in operation. The International at Tooele had five lead furnaces in blast.[1]

Virginia.—The Virginia lead production increased from 143 tons in 1914 to 457 tons in 1915. The lead was obtained from zinc-lead ores from Wythe County. Lead and zinc prospects are reported in the vicinity of Moore's Store, Shenandoah County, but no production is reported. It is reported that prospecting on the Holladay property in Spottsylvania County has developed a considerable quantity of lead-zinc sulphide ore which is being opened by the Virginia Lead & Zinc Corporation. The Allah Cooper mines in Louisa County, operated mainly for the sulphur-content of pyritic ores, recovered some lead as a by-product. It is reported that the Albemarle or Faber property in Buckingham County is being re-opened and will have a new mill for the treatment of mixed lead-zinc sulphide ore.[2]

Wisconsin.—The lead production in Wisconsin has for a number of years been on the decline but in 1915 production again took an increase amounting to 2632 tons as compared with 1819 tons in 1914 and 2639 tons in 1913. The lead concentrate sold in 1915 amounted to 3175 tons valued at $171,091 as compared with 2028 tons valued at $85,196 in 1914. The Bentan district continued to be the largest producer followed by Hazel Green and Livingston.

LEAD PRODUCTION OF THE WORLD

(In metric tons)

Year.	Australasia. (*a*)	Austria. (*a*)	Belgium. (*a*)	Canada. (*a*)	France. (*a*)	Germany (*a*)	Greece. (*a*)	Hungary (*a*)	Italy. (*a*)
1900 ..	87,100	10,650	16,365	28,648	15,210	121,513	16,396	2,030	23,673
1901 ..	90,000	10,161	18,760	23,537	21,000	123,098	17,644	2,029	25,796
1902 ..	90,000	11,264	19,504	10,411	18,817	140,331	14,048	2,243	26,494
1903 ..	106,006	12,162	22,263	8,226	23,258	145,319	12,361	2,057	22,126
1904 ..	117,895	12,645	23,470	17,241	18,800	137,580	15,186	2,104	23,475
1905 ..	106,418	12,968	22,885	25,391	24,100	152,590	13,729	2,146	19,097
1906 ..	93,557	14,846	23,765	24,580	25,614	150,741	12,308	1,925	21,268
1907 ..	96,608	13,598	27,450	21,660	24,800	164,079	13,814	1,468	22,978
1908 ..	119,207	12,669	35,650	19,593	26,112	164,079	15,892	1,544	26,003
1909 ..	77,992	12,941	40,306	23,295	26,927	167,920	14,948	1,590	22,133
1910 ..	105,897	15,476	40,715	14,967	20,226	159,851	16,710	2,077	14,495
1911 ..	105,397	18,097	44,308	10,791	23.635	161,287	14,234	1,583	16,684
1912 ..	113,710	19,993	54,940	16,226	31,080	192,618	14,498	1,605	21,450
1913 ..	(*d*)116,000	22,312	35,750	17,089	(*d*) 28,000	(*d*)181,100	18,309	(*e*)1,790	21,674
1914 ..	....	....	....	16,487	....	....	20,684	....	20,464

[1] E. R. Zalinski, *Eng. Min. Jour.*, Jan. 15, 1916.
[2] U. S. Geol. Surv.

Year.	Japan. (a)	Mexico. (a)	Russia. (a)	Spain. (a)	Sweden. (a)	United Kingdom. (a)		United States.	Totals. (f)
						Foreign Ores.	Domestic Ore.		
1900	1,877	63,827	221	172,530	1,424	10,738	24,762	253,204	849,168
1901	1,806	94,194	156	169,294	988	19,639	20,361	253,944	892,407
1902	1,644	106,805	225	177,560	842	9,113	17,987	254,682	901,970
1903	1,728	(b) 94,181	106	175,109	678	14,900	20,278	256,138	916,896
1904	1,803	(e) 95,010	90	185,862	589	6,888	20,155	278,634	957,427
1905	2,272	(b) 101,196	700	185,693	576	7,517	20,977	290,472	988,727
1906	4,305	(b) 73,699	907	185,470	753	6,984	22,691	323,567	986,980
1907	3,067	(b) 76,158	520	(d) 185,800	813	10,880	24,850	322,854	1,011,397
1908	2,910	(b) 127,010	523	188,062	277	11,480	21,336	284,858	1,057,205
1909	3,429	(b) 118,186	(d) 790	179,993	166	8,056	22,822	329,690	1,056,326
1910	3,907	(b) 120,662	(d) 1,200	190,523	355	8,933	21,866	353,186	1,093,043
1911	4,160	(b) 124,605	(d) 1,000	189,810	1,134	10,048	18,278	368,301	1,108,880
1912	3,613	(b) 109,717	(e) 1,000	232,612	1,073	(e) 8,255	17,806	376,947	1,212,252
1913	(d) 3,600	(b) 55,530	(e) 1,000	(d) 203,000	1,235	(d) 30,500	....	396,034	1,142,264
1914	....	....	....	....	....	....	....	485,011	....

(a) From official reports of countries unless otherwise denoted. (b) Exports. (d) As reported by Metallgesellschaft, Frankfurt am Main. (e) Estimated. (f) The totals may be high on account of duplications which cannot be eliminated. (g) From *Eng. Min. Jour.*

Lead in Foreign Countries

Australia.[1]—Australia produces 10 per cent. of the world's lead production, most of it from Broken Hill, New South Wales. The following table shows sale of the Broken Hill Proprietary Co.'s output by half years in tons:

Destination.	1913.	1914.	1914.	1915.
Europe	30,606	22,341	13,896	1,100
India, China, and Japan	7,020	12,968	8,432	12,075
Australia and New Zealand	4,686	5,100	5,475	4,337
Vladivostock (eastern Siberia)	......	......	......	1,450
Total	42,312	40,409	27,803	18,962

Shipments to Vladivostock were for the Russian government.

Canada.—Although there was an increase of nearly 25 per cent. in the production of lead the 1915 output has been exceeded in 6 of the past 15 years. The production of lead in 1915 was 45,377,065 lb., which, valued at 5.60 cts. per lb., the average price of pig lead in Montreal for the year would be worth $2,541,116. The production in 1914 was 36,337,765 lb., valued at $1,627,568, or an average of 4.479 cts. per lb. The 1915 production consists chiefly of pig and manufactured lead produced at Trail, B. C., but includes also an estimate of the lead probably recoverable from ores shipped to smelters outside of Canada. The entire output of the Surprise mine in the Slocan District, B. C., was shipped to the United States refined in bond, and sold in London.

The exports of lead in ore, etc., in 1915 are recorded by the Customs Department as 1,845,100 lb., valued at $40,273 and of pig lead 2,066,929

[1] *Min. Sci. Press*, Dec. 11, 1915.

lb., valued at $79,067. Exports in 1914 were 246,100 lb. of lead in ore and 510,573 lb. of pig lead.

The total value of the imports of lead and lead products in 1915 was $2,479,261 as against $1,042,538 in 1914. The 1915 imports include 42,616,200 lb. valued at $2,010,006, manufactured lead 3,102,838 lb. valued at $184,581, other manufactures valued at $102,439, litharge 1,579,800 lb. valued at $89,232 and lead pigments 1,709,035 lb. valued at $93,003. The imports of litharge and pigments would contain approximately 1565 tons of metallic lead and the total import of lead would therefore exceed 24,425 tons as shown by this record. The imports in 1914 were equivalent to about 10,869 tons.

The average monthly price of lead in Montreal varied between a minimum of 4.27 cts. in January and a maximum of 6.61 cts. in December, averaging for the year 5.60 cts.

China (By T. T. Read).—It is difficult to get any exact idea of the production of lead in China, as a good deal of the lead ore is smelted with silver ores, the bullion cupelled, and the litharge thus produced is converted into red oxide and sold as pigment. The largest single producer of lead ores is the Shui-Kuo-Shan mine, in Hunan, which was fully described in the *Mining and Scientific Press* of May, 1915. This produced 7625 tons of lead ore and concentrates in 1914, which was sold to the local agents of a German firm that had a contract for the output of this mine. The war has interfered with shipments to Europe, and lately sales have been made to other buyers, while the company is planning to start a lead smelter of its own as soon as it can do so.

Market.[1]—A serious crisis has developed in the import trade in lead in Hongkong, affecting directly and vitally the lead trade in all China, and a number of industries dependent upon supplies of the metal for existence are in serious straits. Lead, pig and bars, was imported into China in 1914 to the amount of 7256 short tons, valued at $577,597, as compared with 7502 short tons, valued at $562,176, in 1913, while sheet and "tea" lead was imported to the amount of 230 short tons, valued at $21,505, compared with imports of 246 short tons, valued at $22,574, in 1913. Nine-tenths of all these imports come from Australia direct or through Hongkong, the latter port directly handling about two-thirds of the whole.

The Australian Government has just stopped the export of lead from that Commonwealth as a war measure, and for the time being the Hongkong market and through it the Chinese markets are practically without supplies. Small amounts of lead are imported into China in ordinary years from Japan, Great Britain, and Russia, but the supplies from

[1] *Comm. Rept.*, Oct. 23, 1915.

Europe for the time being have been shut off and at present there is no supply of a material sort coming from other sources.

The effect of the shortage of the metal is felt particularly in the tea trade, the larger portion of the supplies being used for manufacturing the lead sheets with which tea chests are lined to protect the tea from dampness. Various other industries, like the pewter industry at Swatow, are likely to suffer seriously. Arrivals of lead the present year have amounted to only about 3000 tons. The price quoted at present is £23, or about $112 gold per ton, as compared with about £14, or $68 gold per ton a year ago. There are about 1000 tons of the metal now in stock in Hongkong—about half the usual stock.

France.—Lead imports into France for the first 11 months of 1915 were 47,641 metric tons, as compared with 50,908 tons for the corresponding period of 1914, and 51,602 tons for the year 1914. Exports for the first 11 months amounted to 1,594 tons, as compared with 6650 tons for the same period of 1914, and 6660 tons for the year 1914.[1]

Great Britain.—The preliminary production figures for 1915 report a lead-ore production of 20,698 long tons, as compared with 25,988 tons in 1914.

The imports for 1915 total 256,476 tons of lead, as compared with 224,194 tons in 1914 and 204,290 tons in 1913.[2]

The following table gives the imports of lead into England from the principal exporting countries for the last 3 years:

	1912.	1913.	1914.	1915.
Spain	75,466	77,596	93,145	99,155
Australia	60,292	72,252	68,519	83,221
United States	28,279	24,155	31,048	52,058
Mexico	17,757	10,380	1,735	250

India.[3]—There was a very marked increase in the output of lead ore and slag from the Bawdwin mines in 1914, the ore increasing from 3939 tons in 1913 to 8769 tons in 1914, while the slag increased from 13,360 tons to 24,901 tons. The slag heaps left by the old Chinese miners are gradually becoming exhausted, and in a short time this source of lead will no longer be available. The output of ore, however, has increased considerably. The amount of lead extracted was 10,548 tons in 1914, against 5,858 tons in 1913. Outside of this location the lead production of India is negligible.

Spain.—On the outbreak of hostilities, owing to financial reasons, difficulties in shipment, and other adverse circumstances, the production

[1] Statistics of L. H. Quin.
[2] Statistics of L. H. Quin.
[3] *Rec. Geol. Surv. India*, **45**, 169 (1915).

of lead for the time was reduced to probably slightly over half the normal average output; subsequently, as the situation improved and the original difficulties were overcome, the production of lead has gradually increased as from the beginning of this year, and the production of lead in Spain at the end of the year is probably over three-quarters of its normal average.[1]

The Spanish exports for the year were 149,179 metric tons of soft lead and 12,143 tons of argentiferous lead a total of 161,322 tons, as compared with a total of 148,996 tons for the year 1914.[2] At the outbreak of the war, the Spanish exports suddenly dropped to about 30 per cent. of the previous average, but immediately began to recover gradually, and by the middle of 1915 had reached its previous level.

While northeastern Spain is rich in lead, most of the lead foundries of Spain are controlled by foreign capital. Recently an enterprise in Barcelona has built a lead foundry in a suburb of this city on the left of the Llobregat River delta near principal lines of communication by land and water. This new work marks an advance, and it is hoped there that it will encourage the investiment of capital for the further exploitation of the mineral resources of this region.[3]

Transvaal.[4]—There were shipped in 1914 from the Transvaal £1396 worth of galena, and the production latterly appears to have been anything up to 200 tons per month, valued at about £10 per ton. Mining was carried on somewhat spasmodically during 1914, when returns began to be sent in again after a long interval of non-production. Supplies are coming now from the Kalkheuvel range, which can be seen across the valley north of the Rand, and at present prices there seems to be a profitable opening for small concerns. The Zeerust district, which was the main source of galena supply a few years ago, has apparently ceased to be a factor in the export trade.

Recent Improvements in Lead Smelting

By H. O. Hofman

Introductory; Physical Properties; Alloys; Compounds

Primary Lead.—The following chemical analyses of market lead, not previously published, give the character of the product sold at present. Of special interest are the bismuth content of brands of desilverized lead, and the difference in Missouri leads which have been purified by the Parkes process and those that have not.

[1] *Min. Jour.*, Nov. 6, 1916.
[2] Statistics of L. H. Quin.
[3] *Comm. Rept.*, Oct. 29, 1915.
[4] *So. Afr. Min. Jour.*, Nov. 13, 1915.

TABLE I.—NEW CHEMICAL ANALYSES OF PRIMARY LEAD

Component	U. S. Metals Ref. Co.	Amer. S. & R. Co.						Balbach S. & R. Co.	Inter. Lead Ref. Co.		St. Louis S. & R. Co.		
	Ref. Lead Electrolyt., Per Cent.	B. S. Lead, Per Cent.	B. S. Lead, Per Cent.	B. S. Lead, Per Cent.	Ref. Lead, Per Cent.	Ref. Lead, Per Cent.	Ref. Lead, Per Cent.	Ref. Lead, Per Cent.	Common Lead, Per Cent.	Refined Lead, Per Cent.	S. E. Mo. Undesilv., Per Cent.	S. E. Mo. Desilv., Per Cent.	S. W. Mo. Undesilv., Per Cent.
Cu	0.0010	None	None	None	0.0005	None	0.0005	0.001	0.0006	0.0004	0.0800	0.0003	0.0190
Ag	0.20	0.00072	0.00047	0.00053	0.00075	0.00064	0.00079	0.0003	0.0006	0.0002	0.0080	0.0005	0.0005
Bi	0.0015	0.0418	0.0225	0.0366	0.0850	0.0643	0.0700	0.079	0.0672	0.040	Trace	Trace	Trace
Cd	......	......	......	......	......	......	......	......	......	......	......	......	......
Sn	......	......	......	......	......	......	......	......	......	......	......	......	......
As	0.0003	None	None	None	None	None	None	0.0003	0.0010	0.0005	Trace	Trace	Trace
Sb	0.0030	0.0047	0.0042	0.0040	0.0066	0.0084	0.0094	0.0046	0.0062	0.004	0.0030	0.0020	0.0020
Ni	Trace	None	None	None	None	None	None	......	......	......	0.0080	None	0.0018
Co	Trace	......	......	......	......	......	......	......	......	......	0.0080	None	0.0018
Fe	0.0015	0.0008	0.0010	0.0008	0.0014	0.0012	0.0014	......	......	......	0.0015	0.0015	0.0015
Zn	Trace	0.0026	0.0024	0.0024	0.0034	0.0036	0.0034	0.0008	......	......	Trace	0.0004	Trace
Mn	......	......	......	......	......	......	......	......	......	......	......	......	......
S	None	......	......	......	......	......	......	......	......	......	......	......	......
Insol.	......	......	......	......	......	......	......	......	0.0004	0.0002	......	......	......
Pb	99.9920	99.94938	99.96943	99.95567	99.90235	99.92186	99.91451	99.9143	99.9246	99.9549	99.8995	99.9953	99.9752

Secondary Lead.—According to the official report of the U. S. Geological Survey[1] the secondary lead recovered in 1914 was 61,062 tons or 11.3 per cent. of the primary refined lead; the corresponding figures for 1915 are 78,900 tons, and 14.3 per cent.

Lead Wool.—The use of lead wool for joints of cast-iron pipes is strongly recommended by C. E. Reinicker.[2] An inspection of 200 joints 24 and 36 in. in size, which had been exposed to greatly varying temperatures and vibrations in manufacturing plants proved that only 5.9 per cent. were not absolutely gas-tight. On the other hand, cemented joints gave much trouble being subject to attack by electrolysis.

Lead-arsenic.—This alloy series has been again investigated by W. Heike.[3] This time the alloys were inclosed in porcelain tubes before heating in an electric furnace. The freezing-point curve shows two branches meeting in a eutectic point at 280° C. and at 3.5 per cent. arsenic. Extrapolation of the curve gives the melting point of arsenic as 852° C.

Lead-thallium.—Some of the properties of this alloy-series have been studied by L. Rolla[4].

Bearing Metal of Lead-copper.—It is stated by E. D. Gleason[5] that an alloy made up of equal weights of lead and copper makes a good bearing metal which is suited especially for high-temperature work, and for machinery exposed to acids.

[1] *Min. Res. U. S.*, **1**, 17 (1914).
[2] *Gas Age*, **35**, 325 (1915).
[3] *Internat. Jour. Metallography*, **6**, 49 (1914); through *Jour. Inst. of Metals*, **12**, 291 (1914).
[4] *Gaz. Chim. ital.*, **54**, 185 (1915), through *Chem. Abstr.*, **9**, 2369 (1915).
[5] *Metal Industry*, **6**, 318 (1914).

Lead-copper-nickel.—This system has been studied by Parravano-Mazzetti.[1]

Die-casting.—Alloys for die-casting are divided by E. F. Lake[2] into three classes, having lead, zinc, and tin as bases. Table II gives the compositions of alloys with lead as a base.

TABLE II.—LEAD-BASE ALLOYS FOR DIE-CASTING

Trade Name.	Lead, Per Cent.	Antimony, Per Cent.	Tin, Per Cent.
Electrotype	93	4	3
Russian railroad car	90	8	2
Ordinary bearing	87	7	6
Antimonial lead	87	13	....
Jacoby metal	85	10	5
Linotype	83	12	5
Antimonial lead	80	20	....
Magnolia	80	15	5
Bearing	80	10	10
Railroad bearing	75	15	10
Monotype	74	18	8
Standard white metal	71	24	5
Graphite metal	68	17	15
Railroad bearing	65	25	10
Railroad bearing	60	20	20
Standard type	58	26	15[1]

[1] One per cent. copper also added.

These alloys have low melting points, are easily cast, but are weak. The effect of antimony is to lessen shrinkage and to increase hardness; shrinkage is reduced progressively until the alloy contains 13 per cent. Sb, its effect falls off until a minimum is reached with 35 per cent., it rises to a maximum with 50 per cent. and then falls off again. Alloys with 17.3 per cent. Sb have the greatest hardness. Bismuth is said to be twice as effective as antimony in causing an alloy to fill the mould.

Dissociation of Higher Oxides of Lead.—W. Reinders and L. Hamburger[3] studied the dissociation temperatures of the higher oxides of lead. They find that yellow PbO is the stable phase at elevated temperatures, that the red oxide does not change its color at 540° C., that there exists a continuous series of solid solutions from PbO_2 to $PbO_{1.36}$, and that from this point down to PbO there is formed a mixture of PbO and $PbO_{1.36}$.

Lead Oxide-Cupric Oxide.—This system has been studied by J. C. J. Cunningham[4] up to 70 per cent. CuO; he finds that the two oxides form an eutectic with 32 per cent. CuO freezing at 698° C., and that there is no indication of a chemical compound. The existence of an eutectic explains the fact observed in cupelling that a coppery litharge runs much hotter than one which is free from copper.

[1] *Gaz. Chim. ital.*, **44**$_2$, 375 (1914), through *Chem. Abstr.*, **9**, 1025 (1915).
[2] *Mechanical World*, **56**, 64 (1914), through *Inst. Met.*, **12**, 3041 (1914).
[3] *Zeit. anorg. Chem.*, **89**, 71 (1914).
[4] *Zeit. anorg. Chem.*, **89**, 48 (1914).

Lead Sulphide-Antimonious Sulphide.—This system has been studied by Pelabon.[1] He found an eutectic with 22 mol. PbS and 78 mol. Sb_2S_3 freezing at 482° C., one hidden chemical compound $PbS.Sb_2S_3$ (zinkenite) at 568° C., and another $2PbS.Sb_2S_3$ (jamesonite) at 610° C.

Silver-Silver Sulphide.—This series of alloys has been investigated by C. C. Bissett.[2] The pure sulphide melts at 815° C.; mixtures containing from 17.25 to 95.24 per cent. Ag_2S separate into two layers at 903° C.; an eutectic with 99 per cent. Ag_2S freezes at 804° C.

Lead Ores

Litharge.—A mineral of the composition PbO, 97.17; CuO, 2.61; Sb_2O_3, 0.30 has been found in Persia.[3] It appears to be orthorhombic, and has a specific gravity of 8.61.

Jamesonite.—A deposit near Zimapan, Hidalgo, Mexico, containing this mineral and assaying less than 8 per cent. lead and 4 per cent. antimony is described by R. W. Raymond.[4] Concentration tests have furnished a product with 25 per cent. lead and 15 per cent. antimony. Blast-roasting experiments have shown that antimony and arsenic can be expelled as oxides with the sulphur to such a degree, that the remaining sinter retains little of this element and can serve as collector for precious metal when smelted in the blast furnace with siliceous silver-bearing ores.

Purchasing of Ores.—This important subject has so far received little attention in comparison with other branches of metallurgy. The pamphlet by C. H. Fulton: "The Buying and Selling of Ores and Metallurgical Products"[5] will therefore be welcomed by all metallurgists. In it the author discusses in simple and clear language the prevailing methods and makes clear the points which in most cases have been somewhat obscure. Taken in conjunction with the paper by L. S. Austin noted last year[6] the subject of the purchase of lead ores is well covered.

Smelting Practice

O. H. Hahn.—The death of Otto H. Hahn, the veteran lead smelter, on July 26, at Jena, Germany, at the age of 70 years[7] deserves to be made a matter of permanent record in these reviews.

Smelting and Refining of Lead.—The paper with this title, prepared by H. O. Hofman for the International Engineering Congress in San Fran-

[1] *Compt. rend.*, **156,** 705 (1913); earlier work by Wagmann, see Mineral Industry, **21,** 540 (1912).
[2] *Trans. Chem. Soc.*, **105,** 1223 (1914); *Jour. Inst. Met.*, **12,** 293 (1914).
[3] A. Scott, *Mineral Mag.*, **17,** 143 (1914).
[4] *Eng. Min. Jour.*, **99,** 9 (1915).
[5] *Technical Paper* 83, U. S. Bureau of Mines, 1915.
[6] Mineral Industry, **23,** 469 (1914).
[7] *Eng. Min. Jour.*, **100,** 362 (1915).

cisco[1] reviews briefly the progress which has been made during the last 10 years in these branches of metallurgical endeavor.

Smelting in the Ore-hearth.—The smelting of lead ores in the ore-hearth is restricted to non-argentiferous galena with not less than 68 per cent. lead. Two of the main disadvantages of the method are the small output per man, and the hot, hard, and unsanitary character of the work. The Newnam ore-hearth[2] overcomes these by a rabbling machine which does mechanically the work which has always required hand labor. The machine is hung from an electric carriage traveling on an overhead track. Assuming it to be at rest at one end of the hearth, a lever is pulled to start the machine on its path to the other end. The arm has a motion similar to that of the hand-rabble. Whenever the rabble-arm is withdrawn from the fire, the carriage moves forward a distance of 4 in. and starts the arm on the next stroke. When the machine has arrived at the other end of the hearth, it stops, withdraws the arm from the fire, and returns to its original position. While the mechanical arm rabbles the charge, one man (the helper) follows it, pushes back loose charge with a long-handle shovel, picks out gray slag and delivers it onto the apron plate. He is followed by a second man (the charger) who transfers the gray slag to the water-box, spreads a thin layer of ore on the charge as fast as it is shoveled back by the helper, and adds coke breeze as needed. By the time the trip down the hearth has been completed, the ore first charged is ready to be rabbled. In a comparative test of 4 weeks' duration with galena concentrate assaying 72.5 per cent. Pb and 15.1 per cent. S, the 8-ft. ore-hearth treated 13,179 lb. ore, produced 6443 lb. pig lead and 3318 lb. gray slag (Pb, 43.7; FeO, 12.8; CaO, 9.9; S, 1.9; Insol. 12.6 per cent.); used 3.6 per cent. coke breeze, and made 37.2 rabble trips per hr. The figures for the hand ore-hearth were, ore 5091 lb., pig lead 2030 lb., gray slag 1329 lb. (Pb, 45.0; FeO, 12.2; CaO, 9.0; S, 26; Insol. 12.2 per cent.), coke breeze 8.8 per cent. Of 100 lb. lead in the ore, the Newnam hearth recovered 67.44 as pig lead, 15.18 as gray slag, and 17.38 as dust and fume; with the hand ore-hearth the figures were pig lead 55.00, gray slag 16.20, and dust and fume 28.20 per cent. In the gray slag produced by the parallel tests the lead was present as $PbSO_4$, 10.0; PbS, 6.0; PbO, 25.0; Pb, 8.5; total, 49.5 per cent. Dust and burnt fume were formed in the proportion of 1 lb. dust to 2 lb. fume. The dust assayed Pb, 62.0 and S, 11.1 per cent., the lead being distributed as $PbSO_4$, 18.9; Pb, 55.4; PbO, 2.0 per cent. The burnt fume assayed Pb, 76.0 and S, 5.9 per cent., the lead being distributed as $PbSO_4$, 53.6; PbS, 1.2; PbO, 41.5 per cent. The sulphur elimination with the Newnam ore-hearth was 87.9 per cent., with hand ore-hearth 80.6 per cent. Treatment of a

[1] *Trans. Internat. Eng. Cong.*, 1915.
[2] W. E. Newnam, *Bull. Amer. Inst. Min. Eng.*, Oct., 1915, p. 2139.

galena concentrate with Pb, 82.0 and S, 11.2 per cent. gave per 8-hr. shift the following figures: ore 14,436 lb., pig lead 10,790 lb., gray slag 1075 lb., coke breeze 2.4 per cent., limestone 2 per cent. The percentage of the lead in the ore recovered in the products was, pig lead 91.15, gray slag 4.25, dust and fume 4.60 per cent.; the sulphur elimination 94.7 per cent. Smelting flue dust, containing 62 per cent. Pb and pugged with a binder not named, and burnt bag-house fume containing 76 per cent. Pb, the two mixed to contain 67 per cent. Pb, and using 10 per cent. coke-breeze to make up for the lack of sulphur, gave as pig lead, 81.3 per cent. of the lead charged, as gray slag 10 per cent. (Pb, 32.4; FeO, 14.7; CaO, 11.1; S, 1.2; Insol. 18.72), and as fume 8.7 per cent.

Poling of Lead.—J. O. Bardill[1] describes with illustration his apparatus used for several years at Herculaneum, Mo., for poling lead. The leading parts are two connecting concentric pipes; the inner pipe, open at the ends, is screwed at the top into a cap which closes the outer and has an opening 0.02 in. in diam. leading into the cylindrical receiver filled with sponges and connected with pressure water. The outer pipe, screwed at the top to the cap of the inner pipe and sealed at the bottom, forms a generating chamber from which steam is withdrawn at the side through an elbow carrying a delivery pipe downward parallel with the chamber. The whole apparatus is lowered into the lead held in a kettle, and heated by the lead. Water is admitted through the small opening to the inner pipe and vaporized in its passage downward the inner and upward the outward pipe; near the top of the latter the steam passes off into the delivery pipe and stirs the lead. The apparatus is cheap, effective, and easy to handle.

Sulphatizing Roast.—B. Dudley, Jr.,[2] discusses in a general review from the standpoint of the laws of physical chemistry, the reactions that take place in a sulphatizing roast. Curves and tables are given. A new feature is the acceleration of the dissociation of a metallic sulphate in the presence of a catalyzer. Thus 1 gm. of $Al_2(SO_4)_3$ heated alone to 800° C. was decomposed in 4.5 hr. with a volume-ratio of $SO_3:SO_2$ of 11; heated with 0.2 gm. Fe_2O_3 the time was the same, but the ratio of $SO_3:SO_2$ was 0.73. Heated with platinized asbestos containing 0.025 gm. Pt, the time required was 1.5 hr., while the ratio of $SO_3:SO_2$ was the same as with Fe_2O_3.

Roasting Galena.—W. Reinders[3] has subjected the reactions occurring in the system Pb-S-O to a physico-chemical study.

Silver-lead Smelting Works of North America.—The subjoined list[4] gives the silver-lead smelting works of the United States, Mexico and

[1] *Eng. Min. Jour.*, **100**, 969 (1915).
[2] *Met. Chem. Eng.*, **13**, 221, 306 (1915).
[3] *Verslag. Akad. Wetenschappen*, **23**, 596 (1914), through *Chem. Abstr.*, **9**, 1564 (1915).
[4] *Eng. Min. Jour.* **99**, 59 (1915).

Canada, with the number of their blast furnaces and the annual capacities for tons of charge, that is, of ore and flux.

TABLE III.—SILVER-LEAD SMELTING WORKS

Company.	Place.	Furnaces.	Annual Capacity (*a*.)
American Smelting & Refining Co	Denver	7	511,000
American Smelting & Refining Co	Pueblo	7	380,000
American Smelting & Refining Co	Durango	4	146,000
American Smelting & Refining Co	Leadville	10	509,000
American Smelting & Refining Co	Murray	8	657,000
American Smelting & Refining Co	East Helena	4	306,600
American Smelting & Refining Co	Omaha (*c*)	2	82,000
American Smelting & Refining Co	Chicago (*c*)	2	60,000
American Smelting & Refining Co	Perth Amboy (*c*)	3	140,000
American Smelting & Refining Co	El Paso	7	380,000
Selby Smelting & Lead Co	Selby	3	210,000
Ohio & Colorado Smelting Co	Salida, Colo.	4	345,000
U. S. Smelting Co	Midvale, Utah	6	500,000
Needles Smelting Co	Needles, Cal. (*d*)	2	70,000
Pennsylvania Smelting Co	Carnegie, Pa	2	60,000
International Smelting Co	Tooele, Utah	5	500,000
Totals	United States	76	4,856,600
American Smelting & Refining Co	Monterey	10	475,000
American Smelting & Refining Co	Aquascalientes	2	100,000
American Smelting & Refining Co	Chihuahua	5	274,000
American Smelters Securities Co	Velardena	3	140,000
Compania Metalurgica Mexicana	San Luis Potosi	11	385,000
Compania Metalurgica de Torreon	Torreon	8	360,000
Compania Minera de Penoles	Mapimi (*d*)	6	325,000
Totals	Mexico	45	2,059,000
Consolidated Mining & Smelting Co	Trail, B. C.	3	110,000

(*a*) Tons of charge. (*c*) Smelt chiefly refinery products. (*d*) Not operated in 1914.

Smelting at Salida, Colo.—This smelting plant[1] is situated on a hillside near Salida, Colo. It treats oxide and sulphide lead ore and clinkered residue from zinc retorts. The oxide ore from Leadville is screened, the fines to be treated in the sintering plant; the coarse goes direct to the blast furnace. Sulphide ores, principally from Idaho go to two Godfrey furnaces with hearths 26 ft. in diam. each treating 25 tons per day, and one Wedge furnace, 21 ft. in diam., treating 75 tons per day. The discharge from these furnaces falls on the center of a revolving cast-iron table, is moved toward the edge and there discharged by fixed cast-iron plows, and sprayed with water during its travel. The rough-roasted material mixed to bring the sulphur-content to 15 per cent. is blast-roasted in four Dwight-Lloyd machines, 42 by 264 in., each treating 80 tons charge per day. The use of blast-roasted material has increased the smelting power about 40 per cent. The roasting division has a main flue, 468 ft. long and 166 sq. ft. in cross-sectional area, which ends in a stack 85 ft. high and 12 ft. in diam.; the volume of gas discharged per minute is about 125,000 cu. ft.

There are six lead blast furnaces, two 48 by 100 in. at tuyères and 17

[1] F. D. Weeks, *Bull. Amer. Inst. Min. Eng.*, p. 1961 (1915).

ft. 6 in. high from tuyères to feed floor; and four, 44 by 144 in at tuyères, of the same height; also two copper-matte furnaces which are not used at present. The blast-furnace flue, 245 sq. ft. cross-sectional area and 900 ft. long, ends in a stack 150 ft. high starting 190 ft. above the furnace floor. When smelting 500 tons charge per day, a volume of 63,700 cu. ft. of gas per min. travels through it at a speed of 260 ft. per min. The furnaces are fed by hand. The lead bullion is tapped from the blast furnaces into pots holding 10 bars, and poured into drossing kettles of 39 tons capacity; here it is stirred with compressed air, skimmed into a Howard press and siphoned into bars for shipment, after having been sampled by dipping "gum drops" each of about 0.5 assay ton which are weighed and assayed without trimming. Discrepancies in the assay samples disappeared when the following procedure was adopted: Take off heavy dross at 480° C., blow until temperature reaches 360° C.; skim from time to time, raise to 380° C. and take samples; mould at 425° C.

Smelting at El Paso, Texas.[1]—This smeltery draws oxide and sulphide lead ores from New Mexico, Arizona, western Texas, and northern Mexico. The presence of considerable amounts of copper has an important bearing upon the prevailing smelting practice. The ore arrives on elevated tracks, is unloaded by hand, wheeled on runways, dumped into 20 wooden bedding bins, 8 ft. high with an average capacity of 175 tons, and spread. Large lots of ore which cannot be accommodated in the bins are unloaded in stock-piles and reloaded into railroad cars by a Browning locomotive crane.

From each carload, lumps over 6 in. in diam. are set aside to be sampled in a Vezin machine which makes a cut of one-tenth; while from the fines every tenth shovelful is reserved as sample and added to the cut made by the machine. The mechanical sampling plant has one 75-hp. motor, one No. 6 Gates crusher with a capacity of 45 tons per hr., one 14-in. bucket elevator, one Vezin sampler 52 in. in diam. over the wings making a one-fifth cut, one set of 14 by 36-in. rolls, one 10-in. bucket elevator, two smaller Vezin samplers of which the combined sample equals one-half of the stream of ore. For the further treatment of the combined mechanical sample there are provided two smaller mechanical sampling mills which are practically identical. They contain one 9 by 12-in. Blake crusher, one 8-in. bucket elevator, one set of 12 by 36-in. rolls, one 6-in. bucket elevator, and two Vezin samplers. These furnish duplicate samples of 0.5-in. material weighing from 400 to 500 lb. which are crushed in two 14 by 24-in. rolls, wheeled to the division for reduction by quartering, and finally go to the bucking room to be finished for the sample bottles or bags.

[1] H. F. Easter, *Bull. Amer. Inst. Min. Eng.*, p. 1493 (1915). See also Vail, MINERAL INDUSTRY, **23**, 473 (1914).

Sulphide materials, ore and leady matte go to the sulphide mill of the Huntington & Heberlein plant to be crushed and bedded before they are delivered to the Godfrey rough-roasters. The sulphide mill, which treats about 11 tons per hr., contains one 12 by 18-in. Blake crusher, one set of 16 by 30-in. rolls crushing to 0.5 in., one 12-in. bucket elevator, one 3.5 by 8-ft. trommel with openings ¾ and $^3/_{16}$ in., one set of 6 by 48-in. high-speed rolls for the oversize of the trommel, and an 8-in. bucket elevator to return the rolled material to the trommel.

Ore and matte are bedded with 20 per cent. siliceous sulphides, and go to three Godfrey furnaces of which two are fired with oil, while the third has coal as fuel; its hot coals are used to start the blowing pots. A Godfrey furnace is 26 ft. in diam., treats 30 tons in 24 hr., reducing the sulphur-content from 21 to 10–12 per cent., burns 0.22 bbl. oil or 0.11 ton coal per ton of roasted ore; the actual coal necessary for roasting alone is less. The roasted ore is moistened with a spray of water as it drops from the furnace into a hopper, and passes in a car to the charging floor of the eight H. & H. pots which are suspended 10 ft. above the floor and dumped by a worm gear operated by hand. A pot treats in 24 hr. two charges of 6–7 tons with a blast pressure of about 10 oz. One set of four pots is charged, while the other nears the end of the blow; it is charged in 2 hr. and the full blast is turned on; toward the end of the blow the air supply is diminished. A blown charge is dumped, and the breaking to 8-in. size is done by hand. The fines, amounting to 5–10 per cent., go back to another charge, the sulphur content is reduced to 5 per cent. The broken material goes to bins situated close to the blast-furnace floor on which the charges are made up. The charge materials are wheeled in 400- to 500-lb. units, and dumped into bottom-discharge larry cars, 5 by 10 ft. with a capacity of about 200 cu. ft. or a 5-ton charge. Two hydraulic elevators raise the larries, holding about 4 tons dry weight including the coke, to the feed-floor which is 41 ft. above the furnace floor. The larries, operated by 4-hp. motors, travel over the furnaces, each of which has two parallel openings, 1 ft. 4 in. by 11 ft., closed by counterweighted steel doors. A charge is dropped and distributed by spreaders lower down in the furnace. There are six lead blast furnaces 46 by 162 in. at tuyères representing an area of 47.25 sq. ft. The brick base, 7 ft. 2 in. by 15 ft. 5 in. inside the crucible plates, is 3 ft. 4½ in. high and stands on a flanged steel plate. The crucible is 12 ft. 9 in. long, 2 ft. wide at the bottom and 3 ft. 6 in. at the top; it is 2 ft. 6 in. deep. The lead-well, 12 in. sq. and extending 9 in. above the top of the crucible, is placed 4 ft. 3 in. distant from the front end-plate. There are two tiers of water-jackets; the lower is 46 in. high and has a 9-in. bosh at sides and ends, the upper, 24 in. high, is without bosh; the lower side-jackets are of steel, the others of cast iron. There are four lower jackets to a side, each has two 3½-in. tuyères with centers placed 13 in. above the bottom. The brick shaft, 10 ft. 8 in. by 20 ft. 4 in. outside measurement and 23 ft. high, is supported by 8-in. cast-iron columns; its inside width of 5 ft. 6 in. at the top of the jackets increases to 7 ft. 1 in. at a distance of 6 ft. below the charging-floor which is about the usual level of the ore column. Underneath the floor-plates at the rear, the steel down-take, 3 by 6 ft. conducts the gases to the dust flue, 800 ft. long, varying in cross-section from 151 to 170 sq. ft.; the first 375 ft. of the flue have iron hoppers which discharge into cars, the remaining 425 ft. have side-doors. The dust is removed daily through the hoppers, and once in 3 months through the doors. A furnace treats in 24 hr. 180 tons charge; it makes 1.5 to 2 per cent. flue dust (SiO_2, 16.8; Fe, 17.6; Mn, 0.6; CaO, 8.1; Zn, 4.0; S, 9.0; Pb, 18.2; Cu, 1.2 per cent.; Au 0.30 and Ag 23.5 oz. per ton) which is briquetted with 10 per cent. lime in a Chisholm, Boyd & White press at the rate of 4000 briquettes or 6.5 tons per hr. The briquettes are stacked on pallets, 300 to a pallet, transferred on Scott briquette-cars to a drying shed holding 425 tons, which permits drying for from 3 to 6 weeks. Slag and matte until recently were drawn from the blast furnace into small pots and their contents dumped into two Rhodes separators which are small reverberatory settling furnaces. They were used alternately; the cleaned slag was withdrawn into 3-ton waste-slag cars, and the matte tapped and granulated. These settlers were a distinctive feature of the plant. The small tonnage smelted at present made it difficult to operate them satisfactorily, so they were abandoned and replaced by forehearths. Details of construction and operation are given by the author. The advantages of the furnace were, perfect settling of leady copper matte and cheap preparation for roasting; the disadvantages, cost of transportation of slag-matte, enrichment of copper slag added to the furnace, troubles with speiss and zinc-mush in the absence of coppery slag and corresponding increase in fuel consumption, enrichment in lead of matte, and high cost of the four men necessary for operating the reduced volume of slag-matte. At present a blast furnace is provided with a cast-iron box 2 ft. 6 in. by 9 ft. 2 in. and 2 ft. deep lined with 4½ in. of magnesite brick which serves to collect lead when the well is choked. The slag-matte overflows into an oblong settler, 10 by 20 ft. inside, built into an iron pan which stands on rails running crosswise and is lined at the sides and ends with 9 in. of magnesite brick; the roof is made up of rail-bound fire-brick arches; two oil burners in the center and about 6 in. back from the front, burning 7 bbl. oil per day, furnish the necessary heat; a small stack near the inlet draws off the gases. The slag overflows into waste slag-cars, the matte is tapped into converter ladles. A composite sample of the slag-shells produced in 5 days gave, Au, trace; Ag, 0.64 oz. per ton; Pb, 1.46, Cu, 0.30 per cent.; while the daily 24-hr. samples assayed Au, trace; Ag, 0.30 oz.; Pb, 1.24; Cu, 0.24 per cent.; showing that the settling was satisfactory. The average analyses of a month's products showed: Slag, SiO_2, 33.7; FeO, 27.9; MnO, 1.4; CaO, 22.9; ZnO, 4.6; Al_2O_3, 5.2; Pb, 1.50; Cu, 0.15 per cent.; Ag 0.6 oz. per ton; Matte, 8 per cent. of the charge, Fe, 42.1; Pb, 12.1; Cu, 19.8; Zn, 4.6; S, 21.4 per cent., Au, 0.04 and Ag, 87.8 oz. per ton; Lead bullion, 15.7 per cent. of charge, Au, 3.24 and Ag, 247.6 oz. per ton. There were 2.2 per cent. S on the charge; the coke used was 14.2 per cent. A typical analysis of the zinc-mush sometimes floating on the matte is: Insol., 6.6; Fe, 19; CaO, 3.4; Zn, 24.3; S, 21; Pb, 10; Cu, 4.6 per cent. The lead bullion is tapped into pots, drossed and stirred until clean, and then sampled by dipping "gum-drops" weighing about 40 g. for every bar that is to be cast. A shipping-lot of about 42 tons contains 780 bars; the 780 gum-drops are melted at a low temperature in a graphite crucible, the metal is stirred, then sampled by casting "gum-drops" which go to the laboratory to be assayed without trimming.

Smelting of Mixed Sulphides.—An electric smelting process for the treatment of ores containing sulphides of lead, zinc, and copper has been worked out by W. Menzel.[1] It consists in roasting the ore to such a degree that it will retain not enough sulphur to cover the copper and iron; in smelting the roasted ore in an electric furnace to form matte and slag, and to volatilize all the lead and zinc, made possible by the decomposition of lead and zinc sulphides through metallic copper and iron; in collecting the dust and fume; in leaching the flue dust and electro-depositing the zinc; and in smelting the residue for lead bullion.

Blast-furnace Charge-car.—With modern lead blast furnaces treating as much as 400 and 500 tons charge in 24 hr., mechanical charging has become common practice. Going one step further back, the mechanical making-up of the charge is coming more and more to the front. At the Midvale works of the United States Smelting Refining and Mining Co. there are in operation Brown hoist electric larries for collecting the charges and delivering them to the furnaces.[2] A larry is of 120 cu. ft. capacity; it is driven by a 19-hp. 500-volt D.C. motor at a speed of 600–700 ft. per min.; it contains multiple-beam scales for weighing the charges, a controller for operating bin-gates beneath which it travels to receive the charge components, a foot-brake and drop-bottom gates. The storage-bins for coke, limestone, and iron ore are provided with belt gates; the bins for bedded ores have reciprocating gates which are operated by a 7½-hp. motor on the larry, the connection being made by gearing. When a larry is stopped beneath a gate, the operator connects the gate mechan-

[1] W. Borchers, *Metall-Erz*, **12**, 266 (1915).
[2] Editor, *Eng. Min. Jour.*, **100**, 519 (1915).

ism with the motor on the larry and at the same time breaks the connection with the travel motor.

Calculation of Charge.—A paper on this subject has been written by F. von Schlippenbach[1] in which the usual method followed by lead smelters is detailed in an example for a blast-roasted ore with Pb, 51.0; SiO_2, 8.5; (FeMn)O, 6.5; CaO, 11.0; ZnO, 7.0; Al_2O_3, 2.5; S, 1.51 per cent.; and a slag with SiO_2, 28; FeO, 32; CaO + ZnO, 28; Al_2O_3, 7 per cent. It will be seen that ZnO is figured in as replacing CaO, and that the total of CaO + ZnO is not to exceed 28 per cent.

Smelting Storage Battery Residues.—W. C. Smith[2] records the fact that in smelting the material in a 40-in. circular blast furnace the top invariably became hot. The cause of the unwelcome occurrence is believed to lie in the presence of considerable amounts of PbO_2 in the residues. As PbO_2 is readily decomposed by heat into PbO and O, the O set free near the top of the charge will combine with C and CO generating heat. The remedy lies in heating the residues to form PbO before they are charged, or in reducing the amount added to the blast furnace to about 10 per cent.

Hot-top Blast Furnace.—W. D. Kilbourn[3] has tried to prevent the formation of a hot top in a lead blast furnace at Tooele, Utah, by coating the coke with a fusible material rich in lead which does not readily give off oxygen. A mixture of lead sulphate and oxide with other lead-free substances containing about 60 per cent. lead has worked satisfactorily.

Normal Blast-furnace Work.[4]—The waste gases of a blast furnace contain from 0 to 1.5, usually not over 0.5 per cent. O by volume; if 0.5 per cent. is exceeded, the reduction is poor. In using much blast-roasted ore on the charge, some lead sulphide is likely to remain undecomposed and to be dissolved by the slag. Fumes arising from liquid slag discharged over the dump have shown to contain as much as 52 per cent. Pb. The percentage of lead in the matte forms a valuable means of judging of the degree of reduction obtaining in the furnace; with 12 per cent. Pb in matte, the lead content of slag will be about 0.5 per cent.; with 22 per cent. in matte, it will be 2–2.5 per cent. in slag.

Melting out Slag Notches.—D. H. Browne[5] has advocated an ingenious way of opening up a frozen tap-hole. The apparatus consists of an iron pipe, sufficiently long for protection of the operator from flying sparks, connected by a short piece of strong hose with a cylinder holding oxygen under pressure. The pipe is brought to a red heat and the oxygen turned on when the iron begins to burn. The scintillating end of the pipe is

[1] *Metall-Erz*, **12**, 399 (1915).
[2] *Eng. Min. Jour.*, **100**, 18 (1915).
[3] U. S. Patent 1148782, *Eng. Min. Jour.*, **100**, 313 (1915).
[4] Anon, *Min. Sci. Press*, **91**, 94 (1915).
[5] *Min. Sci. Press*, **109**, 994 (1914).

introduced into the frozen slag-tap, when the combined effect of the intense heat and the fluxing action of the nascent FeO quickly remove the obstruction in the tap-hole. This procedure is in operation at Sulitjelma, Norway, for opening up the matte-tap of a copper reverberatory furnace.[1]

Granulating of Matte.—An apparatus for granulating matte is described with diagram by P. E. Barbour.[2] It consists of slag-pot, lined with fire-brick and provided with an opening 1.25 in. in diam., and set on a brick foundation; a 2-in. water-pipe with nozzle 1 in. in diam. furnishes the pressure-water; a deflecting apron in the foundation diverts the granulated matte to a receiving car.

Slag Constitution.—The binary systems Mn_2SiO_4–Ca_2SiO_4, Mn_2SiO_4–Mg_2SiO_4 and $MnSiO_3$–$FeSiO_3$ have been studied by S. Kallenberg.[3] He found that solid solutions are formed in each case.

High-lime Slags.—Previous to 1878[4] the slags made in lead blast furnaces ran high in iron, following the European custom, when Anton Eilers at Salt Lake City replaced some of the ferrous oxide by calcium oxide. The result was that slags higher in SiO_2 could be made and that they were specifically lighter, also that less sows were made, and that the production of speiss was greatly diminished. A. Eilers[5] states that the credit of first using high-lime slags belongs to A. Raht. The following two slags were made by him in 1881: Slag I contained SiO_2, 33.9; FeO, 26.8; CaO, 26.1; BaO n.d., Al_2O_3, 10.8; total, 97.6 per cent.; Pb, 0.6 per cent.; Ag none; it was produced with coke 15.2 per cent., lead-content of charge 18.7 per cent., silver-content of lead bullion 163 oz. per ton, blast pressure 5.5. oz. per sq. in. Slag II contained: SiO_2, 35.0; FeO, 25.4; CaO, 24.9; BaO, 3.2; Al_2O_3, 9.3; total, 97.8 per cent.; Pb, 0.8 per cent.; it was produced with coke 14.0 per cent., lead-content of charge 20.1 per cent., silver-content of lead bullion 152 oz. per ton, blast pressure 6.75 oz. per sq. in. Mr. Eilers shares with the late A. Steitz the construction of the cast-iron water-jacket with open neck, universally used at present.

Bretherton records an experience in Nevada where he smelted two ores, one with Pb, 3.5; Fe, 6; Mn, 2.5; Zn, 7; CaO, 21; MgO, 11.7; SiO_2, 8.5; Al_2O_3, 1; As, 3 per cent.; S, trace; the other with Pb, 11.5; Fe, 20; Mn, 0; Zn, 4; CaO, 3; MgO, 0; SiO_2, 30 per cent.; S, trace; As, trace; making a high-lime slag and producing no speiss whatever. The lead-bullion produced was enriched in precious metal by cupelling at the rate of 8 tons in 24 hr., and the litharge formed returned to the blast furnace as lead ore. The author also notes that increase of blast with heightening of ore-

[1] Offerhaus, *Eng. Min. Jour.*, **100**, 1033 (1915).
[2] *Eng. Min. Jour.*, **99**, 239 (1915).
[3] *Zeit. anorg. Chem.*, **88**, 355 (1914).
[4] Bretherton, *Bull. Amer. Inst. Min. Eng.*, 1595 (1915).
[5] *Op. cit.*, p. 2479.

charge became only feasible when the use of charcoal was given up, as otherwise overfire would quickly have resulted.

Slag Granulation.—A vertical section through a slag-granulating device is given by P. E. Barbour:[1] high-pressure water strikes the stream of slag flowing from a spout; and low-pressure water furnishes the volume of water necessary to carry off the granules in a race lined with slag-blocks.

Recovery of Zinc from Slags.—At the dismantled National plant of the A. S. & R. Co., at South Chicago, Ill., B. F. Hedges and R. D. Divine have started upon the recovery of zinc from the waste-slag dump.[2] The slag, which averages about 12 per cent. Zn, is smelted with limestone and coke in a blast furnace 46 by 156 in. at the tuyères. The furnace is run with a hot top; the zinc set free in the smelting is volatilized, and collected in a bag-house and a Prinz & Rau dust collector. The new slag is granulated and returned to the dump from which the old slag had been removed by means of an excavating crane. Of the zinc present about 50 per cent. is recovered as oxide, some lead-bullion and speiss are also extracted.

Condensation.—The pamphlet "Metallurgical Smoke" by C. H. Fulton is a timely publication of the U. S. Bureau of Mines[3] in which are discussed the processes employed by smelteries for handling the gases, vapors and fine dust emanating from furnaces. The principles governing the processes are clearly stated; the amply illustrated material which has recently found its way into the technical press has been well utilized.

The full report of the Selby Smelter Commission, edited by J. A. Holmes, E. C. Franklin, and R. A. Gould, has been published as *Bulletin* 98, by the Bureau of Mines. A summary of the metallurgical results was given last year.[4]

Flue Dust.—E. Hentley[5] describes the manner of collecting and handling of flue dust at the Hampden Cloncurry smelting works, North Queensland. The gases pass through a settling flue 27 ft. high and 18 ft. wide in which their speed is reduced to 240 ft. per min.; they then enter a balloon-shaped steel flue 9 ft. high and 7 ft. wide provided with a conveyor to remove the accumulating dust. The conveyor is a ⅝-in. endless chain which passes at one end of the flue over a driving sprocket wheel operated by motor, and at the other over a tail-wheel; on the flues are placed guide wheels. The speed of the chain is about 40 ft. per min.; it is in operation for 2 hr. in an 8-hr. shift, and collects in 24 hr. about 12 tons of dust.

Bag Filtration.—At the works of the U. S. S. R. & M. Co., Midvale, Utah, the bag-house is divided into two parts.[6] The gases from the blast

[1] *Eng. Min. Jour.*, **99,** 239 (1915).
[2] Pulsifer, *Met. Chem. Eng.*, **13,** 783 (1915).
[3] *Bulletin*, No. 84, 1915.
[4] Mineral Industry, **23,** 493 (1914).
[5] *Trans. Inst. Min. Met.*, **23,** 442 (1913–14).
[6] L. S. Austin, *Min. Sci. Press*, **110,** 579 (1915).

furnaces containing 0.1 per cent. volume SO_2 go through one division and then into the atmosphere; those from the roasting furnaces on leaving the other division enter a down-take, 11 by 11 ft., which has near the ground two branches, each of which ends in a No. 20 Sirocco suction fan, 10 ft. in diam., making 100 r.p.m., and requiring 70 hp. against a resistance of 0.54 in. water. The two fans are on a common shaft driven by a 150-hp. motor. The down-take has openings through which air is drawn in; the gas diluted with air to contain less than the legal requirement of 0.75 per cent. volume SO_2 is delivered into a stack, 16 ft. in diam., and rises in it with a velocity of 1/3 mile per min. Additional air for dilution of the SO_2 of the gases can be obtained by opening the lower doors of the upper chamber of the bag-house.

Electric Precipitation.—F. G. Cottrell has given an historical sketch of his process.[1] The subject has been treated theoretically by W. W. Strong[2] and A. F. Nesbit;[3] a review of modern installations is given by L. Bradley.[4] Attention may be called to the extended paper on the subject in the last volume.[5]

The Cottrell process[6] has been introduced in the lead division of the Consolidated Mining & Smelting Co. at Trail, B. C., for the recovery of dust and fume. The condensation plant, which treats 100,000 cu. ft. of gas per min., contains 384 vertical pipes 12 in. in diam. and 16 ft. long. A rectified current of 75,000 volts passes through the central wires; the flue dust collected averages 70 per cent. Pb.

W. W. Strong and A. F. Nesbit[7] have found that an alternating current can be used for the precipitation of fume and dust, provided that under certain conditions the luminous region about the active electrode is extended by the introduction of a spark-gap in series with the active or grounded electrode.

Lead Poisoning in the Manufacture of Storage Batteries.—Alice Hamilton, whose report upon lead poisoning in smelting works was discussed last year[8] has extended her investigation to the manufacture of storage batteries.[9] In this industry the men are exposed to the fume and dust of lead and lead oxide. Statistics show that lead poisoning in Germany attacks 0.97 per cent. of the men employed, in Great Britain 3 per cent., and in the United States 17.9 per cent. They prove that the provisions made for protecting men in this country are very inferior to those of Germany and England.

[1] *Proc. Amer. Inst. Elec. Eng.*, **34**, 625 (1915).
[2] *Op. cit.*, p. 229.
[3] *Op. cit.*, p. 507.
[4] *Op. cit.*, p. 523.
[5] Mineral Industry, **23**, 867 (1914).
[6] G. Guess, *Canad. Min. Jour.*, **36**, 37 (1915).
[7] U. S. Patent, No. 1120561; *Eng. Min. Jour.*, **99**, 240 (1915).
[8] Mineral Industry, **23**, 493 (1914).
[9] U. S. Department of Labor, Bureau of Labor Statistics, *Bulletin* No. 165, p. 37.

Wet Process.—H. Bueler-de Florin[1] gives a more detailed discussion of his process of treating non-ferrous ores with nitric acid than the one published last year.[2]

DESILVERIZATION

Parkes Process.—Effect of Zn_3Ag_2 upon Desilverization.—The study of the freezing-point curve by Carpenter and Whiteley[3] of the alloy-series Ag–Zn has shown the existence of a single chemical compound Zn_3Ag_2 freezing at 665°C. Large-scale experiments were carried out by F. C. Newton[4] at the refinery of the American Smelting & Refining Co. at Maurer, N. J., with the aim to obtain this compound in the zinc crust and to increase thereby its content in silver, thus reducing the amount of crust to be retorted and of rich lead to be cupelled. In ordinary practice, the zinc is stirred into the lead bullion held at about 535° C., and the crust formed is pressed at the same temperature. In the tests the temperature of the lead bullion was brought to 705° C. before the zinc was stirred in, the crusts were then taken off as quickly as formed until the lead became too cool to allow skimming. Six series of experiments were made; they all showed that with increase of temperature the silver content of the crust diminished, and that the common practice of stirring in the zinc at 535° C. gave the best results. The reasons for this result may be surmised, but require investigation for a definite answer.

Silver-zinc.—The electric conductivity of the alloys of silver and zinc, quenched and annealed and their hardness has been studied by Petrenko.[5] The tests appear to confirm in part the research of Carpenter and Whiteley that there exists only one chemical compound, Ag_2Zn_3.

Zinc-silver-lead Alloys.—B. Bogitsch[6] has studied the distribution of the three metals in the two layers of alloys formed at the temperatures at which the upper layer solidifies. The charges, ranging in weight from 10 to 40 gm. and varying in composition, were melted under a cover of chlorides of zinc, potassium and sodium, stirred, cooled slowly to the point at which the upper layer just began to solidify, held there from 2½ to 3 hr. for the separation and diffusion of components, and then cooled quickly. Samples for assay were taken from the top and bottom of each of the layers; the assays of five such samples are given in Table IV.

[1] *Metall-Erz*, **12**, 20 (1915).
[2] MINERAL INDUSTRY, **23**, 494 (1914).
[3] MINERAL INDUSTRY, **22**, 474 (1913).
[4] *Bull. Amer. Inst. Min. Eng.*, p. 474 (1915).
[5] *Jour. Russ. Phys. Chem. Soc.*, **46**, 175, 176 (1914); *Jour. Soc. Chem. Ind.*, **33**, 1211 (1915); *Chem. Abstr.*, **9**, 777 (1915).
[6] *Compt. rend.*, **49**, 178 (1914).

TABLE IV

	Upper Layer.					Lower Layer.				
Button.	I.	II.	III.	IV.	V.	I.	II.	III.	IV.	V.
Ag, per cent....	1.26	17.19	31.00	61.67	55.40	None	0.0034	0.15	24.63	47.3
Zn, per cent....	97.74	58.91	65.38	23.86	5.98	1.35	1.36	1.27	3.45	4.5
Pb, per cent....	1.00	23.9	3.62	14.47	38.62	99.65	99.606	98.58	71.92	48.2

Button V was re-melted with an additional amount of silver and treated as before. The new button showed no layering, but top and bottom assays showed that segregation has occurred, viz., top: Ag, 58.99; Pb, 36.56; Zn, 4.45 per cent., and bottom: Ag, 53.12; Pb, 41.4; Zn. 5.5 per cent. The author traced a triaxial diagram, in which a curve divides the area into two fields: One is the region of two superposed liquids, the other that in which the three metals can exist without liquation. As no isothermals are recorded, the results have only general interest.

Cupellation.—In cupelling lead-bullion one has to consider the loss by volatilization and cupel absorption. With silver there is a greater loss than with gold, but the loss of either is diminished by the addition of another metal. The loss for a given amount of precious metal varies with the amount of lead used, the nature and amount of impurity, the porosity of the cupel, the air supply, and especially the temperature. W. J. Sharwood[1] enumerates these general principles, which hold good for large-scale work, in his endeavor to find a rule governing cupellation losses in assay work. The results of his investigation lead him to formulate the following three rules:

1. When a given amount of silver or gold is cupelled with a given amount of lead under fixed conditions as to temperature, etc., the apparent loss in weight sustained by the precious metal is directly proportional to the surface of the button of the fine metal remaining.

2. The loss in weight varies as the $\frac{2}{3}$-power of the weight, or as the square of the diameter of the button.

3. The precentage loss varies inversely as the diameter of the button, or inversely as the cube of the weight.

Spitting of Silver.—The usual explanation of this phenomenon, solution of oxygen in metal, does not appear to cover the ground on account of the large volume of gas given off. H. B. Baker[2] suggests the formation of an oxide of silver stable at elevated temperature, but dissociated with fall of temperature.

Betts Process.—The preparation of HF from CaF_2 and H_2SO_4 is usually

[1] *Bull. Amer. Inst. Min. Eng.*, p. 1672 (1915).
[2] *Proc. Chem. Soc.*, **30**, 56 (1914).

expressed by $CaF_2 + H_2SO_4 = 2HF + CaSO_4$. According to O. Ruff and H. J. Braun[1] the process taking place is not as simple as is generally held. The water content of the acid, the imperfect yield, the duration of the distillation point to side reactions with the formation of $SO_2F.OH$ free or in combination with CaO. Experiments carried out to find the best method of working showed that the most economic procedure was to use sulphuric acid with 90 per cent. H_2SO_4 (sp. gr. 1.824), to the amount called for theoretically, and to heat for 3 hr. to 200° C. This gave a yield of 81 per cent. Heating for 1 hr. more raised the yield only by 3–5 per cent. Using sulphuric acid with 97–100 per cent. H_2SO_4 gave a yield of 60 per cent. of hydrofluoric acid containing 95–96 per cent. HF.

[1] *Berichte deutsch. chem. Gesellsch.* **247**[1], 646 (1914).

MAGNESITE

By S. H. Dolbear

Magnesite is a natural form of magnesium carbonate that is fairly pure and free from other materials. It consists of a metallic element—magnesium—in combination with carbonic acid, or, as usually expressed, it is composed of magnesia, or oxide of magnesium, 47.6 per cent., and carbon dioxide, 52.4 per cent., and is split up into these two components by heating. Pure magnesite is commonly a white, very fine-grained porcelain-like rock, which is actually minutely crystalline, but very fine and compact.

Magnesite is found in many parts of the world, the deposits of commercial importance belonging to two principal and quite distinct types. The most widely distributed type is fine-grained massive magnesite, which occurs as vein deposits. This type is associated with basic intrusive magnesian rock, which if somewhat altered is generally called serpentine. To this class belong the deposits on the island of Euboea, in Greece, practically all the deposits in California, and deposits in many other parts of the world.

The other form of magnesite is of sedimentary origin or is found in immediate relation to sedimentary rocks, in which it occurs as a massive, more or less coarsely crystalline rock resembling coarse dolomite or marble in texture, an extreme phase of the supermagnesian dolomites. The deposits of Austria and Hungary are of this type, and perhaps also the deposits near Quebec, in Canada.

Magnesite is ordinarily marketed either crude or as the calcined product, but a considerable number of derived and of more or less manufactured products are made wholly or in part from magnesite.

Magnesite as mined, in its crude or natural form, is essentially carbonate of magnesium with some impurities. As such it may be considered a source either of magnesia (magnesium oxide) or of carbon dioxide gas, these being produced by its decomposition by extreme heat or calcining.

Magnesite that has been calcined consists essentially of magnesia (magnesium oxide). In practice the process of calcining is carried out so as to manufacture magnesia in two forms, which have quite different properties, namely, the "caustic" calcined magnesite and the "dead-burned" magnesite. These products are obtained by different degrees of calcination of the raw magnesite.[1]

[1] *Min. Res. of U. S.*, 1914, U. S. Geol. Surv.

Prices.—The price of crude magnesite ranged from $5.50 to $12 per short ton during 1915. Calcined magnesite sold for prices presenting quite as wide a range, namely, from $20 to $60. Hence no fixed price can be said to represent the market, and for purposes of estimation a value of $10 per short ton for crude magnesite has been used in the tables for 1915.

Domestic calcined magnesite in bulk sold for $25 to $30 per short ton F.O.B. San Francisco, or other California points. When ground and packed in barrels the price ranged from $40 to $60 per ton. Powdered Grecian magnesite, where available, brought similar prices at San Francisco. Early in 1915 Austrian calcined magnesite was quoted at $22 to $25 per short ton and Grecian caustic magnesite, not ground, at $29, ships tackle, Atlantic ports.

California.—The domestic production of magnesite in the United States for 1915, was 30,325 tons of crude, which includes 10,951 tons of calcined; as against 11,293 tons estimated as crude, during 1914.[1] The production during 1916 will no doubt greatly exceed that of any former year. Because of the difficulty in securing imports, the demand for the California product has been active and many new mines are now shipping ore. Tulare County continues to be the most important source. The notable development in that County has been the re-opening of the deposits abandoned by the Tulare Mining Co., which were purchased by the Porterville Magnesite Co., and the operation of a new mine of great promise adjoining that of the Tulare Mining Co. on the south fork of the Tule River about 14 miles North-east of Porterville. A rail extension about 5 miles long has been made, and a tramway erected, giving the mine excellent transportation facilities. The development of this mine was commenced by S. R. Cogllan and T. E. Frederick in the later part of 1915, and the mine later was sold to R. D. Adams of the Lindsay Mining Co. Doyle and Smith have opened another new deposit in Frazier Valley, as have Cook and Langley in the vicinity of Deer Creek. At the latter mine an excellent grade of ore is being produced. The California Magnesite Co. operated several leases in the Porterville district and commenced the erection of a large calcining plant. Their operations were later interrupted by litigation.

PRODUCTION IN CALIFORNIA BY COUNTIES

Equivalent in crude tons (2000 lbs.)

Sonoma	3,729
Santa Clara	7,270
Tulare	12,116
Napa	1,050
Other Counties	6,890
	31,055

[1] U. S. Geological Survey.

Aside from the mines mentioned there are many smaller operations in this district yielding one or more car loads per month. Shipments from the Porterville district in May, 1916, reached 127 car loads.

The Tulare Mining Co. continues to remain the largest producer in the State. All of the product from its Porterville mines was calcined, the Company operating two shaft kilns. The Company also made shipments of crude ore from its Napa County deposits.

In Sonoma County, the Sonoma Magnesite Co. completed a rotary calciner and have shipped some calcined material. This was hauled about 14 miles to Guerneville for shipment, the projected narrow gauge railroad not having been completed.

The Refractory Magnesite Co. re-opened the old Creon deposits near Preston, in Sonoma County, and shipped several hundred tons of crude ore which was calcined at the plant of the Pacific Carbonic Gas Co., the carbon dioxide content being recovered. This mine yields an unusual ore, having a greenish cast when mined, due to the presence of iron carbonate. On calcining, the ore becomes a dark brown color, the iron carbonate present being reduced to an oxide which is somewhat magnetic.

At Bissell, in Kern County, the Rex Plaster Co. mined several thousand tons from deposits of sedimentary ore, a part of which was calcined in the company's rotary kiln situated at Los Angeles.

In Santa Clara County the Western Magnesite Development Co. have shipped both crude and calcined ore. The reduction plant is situated near the company's deposit on Red Mountain, and motor trucks are now employed in hauling the product to Livermore, a distance of 35 miles.

At Madrone, in Santa Clara County, H. Sherlock contined to operate deposits and shipped several hundred tons of impure magnesite. This was calcined at the plant of the Pure Carbonic Gas Co. at West Berkley, the carbonic acid gas recovered, and the residue shipped to a paper mill in Oregon, for use in the bisulfite pulp process.

The White Rock mine, in Napa County yielded several hundred tons of crude ore which was shipped from Rutherford. Aside from the more important deposits mentioned above there are many smaller operations being conducted in various parts of the State.

Nevada.—There has been reported the discovery of a large deposit of magnesite in Clark County, Nevada, a few miles from the town of St. Thomas. This occurrence is said to be similar to that at Bissell, in California, which are of sedimentary origin. Magnesite is believed to have been precipitated by contact of solution containing soluble magnesium salts with alkaline carbonates. The following analyses are given as representative:

	1 Per Cent.	2 Per Cent.
SiO_2	11.12	11.82
$Al_2O_3+Fe_2O_3$	.98	.94
CaO	5.36	5.90
MgO	36.72	36.40
Loss on ignition	44.15	43.45
	98.33	98.51

Considering the fact that magnesite buyers have established a maximum admissable limit of 5 per cent. SiO_2, and 3 per cent. CaO., this magnesite would appear to be too low grade to be valuable.

STATISTICS OF CRUDE MAGNESITE IN THE UNITED STATES
(Tons of 2000 lb.)

Year.	Production. (*a*)	
	Tons.	Value.
1903	3,744	$10,595
1904	2,850	9,298
1905	3,933	15,221
1906	7,805	23,415
1907	7,561	22,683
1908	6,587	19,761
1909	9,465	37,860
1910	12,443	74,658
1911	9,375	75,000
1912	10,512	84,096
1913	9,632	77,056
1914	11,293	124,223
1915 (*b*)	30,325	303,250

(*a*) U. S. Geol. Surv.
(*b*) Estimated.

IMPORTS OF MAGNESITE INTO THE UNITED STATES

	1913.		1914.		1915.	
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.
Magnesia:						
Calcined (Medicinal)	54,915	$10,034	159,547	$19,342	94,324	$10,462
Carbonate (Medicinal)	70,823	4,880	46,183	2,527	48,817	2,757
Sulphate	8,121,677	32,884	13,826,899	53,768	3,560,701	16,050
Magnesite:						
Calcined, not purified	334,187,404	1,672,565	243,633,205	1,323,194	53,148,739	392,071
Crude	26,479,109	84,911	26,708,381	54,677	99,527,772	255,140

IMPORTS OF MAGNESITE CALCINED, NOT PURIFIED
(Fiscal years ending June 30, in short tons)

Country.	1912.	1913.	1914.	1915.
Europe:				
Austria-Hungary	99,104	163,715	134,260	52,086
Belgium	25	....	11	....
Germany	689	2,412	2,578	722
Greece	114	1,605	3,232	4,437
Denmark	....	....	58	103
Italy	....	....	....	710
Netherlands	2,410	4,508	4,191	3,054
Norway	163	....	....	....
United Kingdom—				
England	61	1	12	130
Scotland	....	....	1	151
North America:				
Canada	234	350	404	948
Mexico	81	....	....	....
Other countries	(*b*)57	....	....	(*a*)508
Total	102,938	172,591	144,747	63,348

(*a*) Venezuela.
(*b*) British East Indies.

THE PRINCIPAL SUPPLIES OF MAGNESITE
(In metric tons)

Year.	Austria-Hungary. (*a*)		Greece.		India. (*d*)	United States. (*d*)
	Crude	Calcined	Crude	Calcined		
1901	....	40,236	20,348	....	(*e*)	4,286
1902	....	53,467	23,020	....	3,597	2,567
1903	....	69,058	28,415	....	838	1,234
1904	....	53,781	9,133	....	1,193	2,585
1905	....	92,359	37,063	....	2,645	3,568
1906	....	87,765	40,584	....	1,861	7,093
1907	452	113,695	55,816	....	188	(*f*) 6,858
1908	212	87,049	63,079	....	7,655	(*f*) 5,994
1909	1,027	125,666	56,797	16,609	199	(*f*) 8,588
1910	341	182,911	18,073	19,982	5,264	(*f*)11,291
1911	77	182,911	86,956	27,530	3,546	(*f*) 8,505
1912	....	171,196	106,338	33,848	15,626	(*f*) 9,534
1913	....	200,947	118,054	40,972	16,468	(*f*) 8,741
1914	....	....	136,701	28,563	1,706	(*f*)10,248

(*a*) Exports. (*d*) Crude magnesite. (*e*) Not reported. (*f*) U. S. Geol. Surv.

Canada.—The magnesite industry of Canada has been confined to Argenteuil County, Quebec, and up to 1915 has been of small proportions. However, the general shortage of European supplies has caused these deposits to rise considerably, in importance, and the previous production of a few hundred tons a year jumped in 1915 to 14,779 short tons, valued at $126,535. The old producing company, the Canadian Magnesite Co. has been superseded by the North American Magnesite Co.

Greece.—The Grecian production in 1914 increased to 136,701 metric tons, from 118,054 tons in 1913. The amount calcined dropped from 40,972 tons to 28,563 tons. The sales of crude magnesite in 1914 amounted to 54,631 tons, and of calcined, 28,933 tons. Briquettes of magnesite were produced in 1914 to the amount of 493 tons.

India.—The 1914 production dropped to less than 1700 tons from over 16,000 long tons in 1913. The output at Chalk Hills dropped from 14,086 tons to 399 tons, and at Mysore from 2112 tons to 1281 tons.

Italy.—The production of magnesite for 1914 was 740 metric tons, as compared with 600 tons in 1913, from the province of Turin, and 400 tons in the island of Elba. There has been reported at Castiglioncello a considerable deposit of magnesite, carrying 88 to 89 per cent. $MgCO_3$ and 4 per cent. silica.

Mexico.—The International Magnesite Co. commenced shipment of crude magnesite from its deposits on Santa Magarita Island in the Gulf of Lower California. The ore is brought by water to Chula Vista, Cal., near San Diego, where it is calcined in a rotary kiln. The capacity of the plant is stated to be 22 tons of calcined magnesite per day.

Metallic Magnesium[1]

Its chief uses are:

1. Scavenging alloys, *i.e.*, clearing up oxides of other metals and making denser, cleaner, stronger and more homogeneous alloys. Valuable in aluminum, nickel, copper, brass, bronze, etc., and special steels, because of its intense avidity for both oxygen and nitrogen.

2. Alloying with aluminium or aluminium containing traces of one or more of the other metals Cu, Ni, Zn, Pb, Bi, Sb, Fe, etc.; greatly modifies their crystallization and physical properties; alloys readily with most metals and melts at a convenient heat.

3. Illumination, as in military uses for shrapnel trailers, star bombs, flare lights, etc., and in photography for flash lights. Its easy inflammability (about 800° C.), the high heat of combustion (134,000 cal.), the relatively low temperature of vaporization (1100° C.), the intensely white oxide produced and the high temperature of volatilization of this oxide, are the essential factors of these uses.

At present there is being produced at two points in the United States about all the present alloy market will absorb, and an increase of plant is being made of about 25 per cent. of the present capacity. One other producer makes only about his own requirements. Two others are soliciting business but have failed to fill orders—in one case the order is now over a year old and still stands unfilled. All told, we believe the present production is at the rate of something over a million dollars' worth a year and will be slightly in excess of the present domestic needs.

The use of the metal for scavenging purposes depends on price of metal compared with price of material to be scavenegd. For use with

[1] Abstracted from Wm. M. Grosvenor, *Trans. Amer. Electrochem. Soc.*, vol. **29**.

copper, brass, bronze, etc., the magnesium can be used at far higher prices than for steel. But the big consumption of the material can only come when it directly replaces aluminium as the predominant metal in the alloy, and arrives at a correspondingly low price. It makes beautiful castings, machines easily and well, is about a third lighter than aluminium, and can be made about two to four times as strong. The coefficient of expansion reported is practically the same as aluminium. When properly pure (over 99.5 per cent.), it is apparently quite as resistant to corrosion as aluminium, equal if not superior in electrical conductivity (about half that of copper), and superior in heat conductivity (also about half that of copper).

The processes for manufacture are as follows:

1. Reduction of fused $MgCl_2$ by Na.
2. Electrolysis of the fused double chloride, usually $MgCl_2.KCl_2$.
3. Reduction by carbon (patented).
4. Electrolysis of dissolved MgO (applied for).
5. Reduction of fused $MgCl_2$ by aluminium (applied for).
6. Reduction of oxide or carbonate to slag-forming residues (applied for).

And some others.

The first process involves the production of metallic sodium. Existing conditions, the demand for sodium and sodium peroxid, forbid its consideration with a minimum of about 2 lb. of Na consumed for every pound of Mg produced, and the necessity of producing dehydrated fused $MgCl_2$ to start with.

The second process has been perfected and is very largely used abroad. We have commercially used and studied the process here and, with the cheapest water power and chloride, prices under normal conditions by this process must rule above $1 per lb.

The third process, reduction by carbon, is absolutely fascinating in its possibilities. The product is a black or gray powder. Believing such a product would be valuable, the manufacture was carried out on a scale of about 25 lb. (11 kg.) per hr. As the difficulty of selling the product became apparent, much time and effort were devoted to attempts to recover the metal in fairly pure form. Owing to serious objection both on the side of cost and regularity of product this process was superseded.

The other processes will be discussed on some other occasion when the engineering problems they involve are believed to be finally solved in the best way, and the patent office has finished considering them. The chemical side of each has been thoroughly worked out, however, so that some conclusions may be drawn from the large laboratory or small commercial operations. These may be of considerable interest.

At least one of the processes appears to be adapted to produce directly metal averaging 99.6 per cent. purity, in tons per day instead of pounds. Laboratory tests give a raw material cost of 4 cts. per lb. of magnesium, and indicate a fuel cost which approaches 3 cts. as a theoretical limit, though the practical figure will probably be several times as high. The final selection of various possible engineering means and methods remains to be worked out, but it scarcely seems possible that either labor or repairs should exceed 2 cts. per lb. Thus if commercial yields maintain the experimental level, and three times the theoretical power is commercially required, we have prospects of a net factory operation cost (without interest, amortization, insurance, patent, administration or selling) of 17 cts. per lb. If only 75 per cent. yield is obtained, this net factory cost would be about 22 cts. or a total cost with all overhead expenses of 35 cts. and a selling price of 40 cts. to 50 cts. according to tonnage.

It may seem premature to speak of such possible prices in view of present conditions. It is only the present price of $5.50 that justifies or even makes possible the $1000 and $10,000 experiments that have been tried and must be tried again and perhaps again during the next 3 to 5 years, before the tide turns. The men who are doing this work do not cultivate talkativeness as a preference. Just at this time, however, certain consideration of public welfare should take precedence of preference.

Therefore, at the risk of criticism and possible financial sacrifice it seems to be a duty at this time to point out what may possibly be expected of magnesium. Few realize the extent to which it is valuable in military work. One of the great foreign explosive experts stated that he would be glad to pay $1.50 per lb. for 500 tons. A single contract for shrapnel being executed in this country would require about 50 tons. The illuminating bombs to make daylight over the enemies' works and trenches consume large quantities. The trailer attached to shells serves at night to show the effectiveness of the fire. For all these purposes magnesium produces a result that can not be approached by antimony or aluminium. Consider what it means to aeroplane, dirigible, and motor construction, to high-speed engines of every type, to reduce weight one-third and double strength, to have a material that has a density of 1.75 and may be hot rolled to 35,000 lb. per sq. in. (25 kg. per sq. mm.) or cold-rolled very much higher.

MANGANESE

By James Aston

The United States has remained virtually a non-producer of high-grade manganese ores and in spite of the impetus given to the domestic industry because of the shortage of foreign ore, production has not increased in the manner expected. The United States Geological Survey reports the 1915 output to have been 9651 tons, compared with 2635 tons in 1914. The total production of the United States is shown in the following table:

PRODUCTION OF MANGANESE ORES IN THE UNITED STATES (*a*)
(Tons of 2240 lb.)

Year.	Manganese Ores.				Manganiferous Ores.				Man. Zinc Ores.	Total Production.	
	California.	Georgia.	Virginia.	Other States.	Arkansas.	Colorado.	Lake Superior.	Va. & N. C.	New Jersey.	Long Tons.	Value.
1901.	610	4,074	4,275	3,036	*Nil.*	62,385	512,084	20	52,311	638,795	1,644,117
1902.	846	3,500	3,041	90	*Nil.*	13,275	884,939	3,000	65,246	973,937	2,145,783
1903.	16	500	1,801	508	*Nil.*	14,856	566,835	2,802	73,264	660,582	1,670,349
1904.	60	*Nil.*	3,054	32	600	17,074	365,572	*Nil.*	68,189	454,581	789,132
1905.	1	150	3,947	(*e*) 20	3,321	45,837	720,090	*Nil.*	90,289	863,655	1,681,472
1906.	1	....	6,028	892	8,900	32,400	1,000,008	*Nil.*	93,461	1,141,690	(*e*)3,403,993
1907.	100	*Nil.*	(*d*)4,604	900	4,133	(*d*) 99,711	(*d*) 314,316	*Nil.*	93,413	517,177	1,510,156
1908.	321	*Nil.*	(*e*)6,144	200	(*d*) 4,066	(*d*) 51,524	(*d*) 467,140	274	110,225	639,894	1,280,989
1909.	3	*Nil.*	1,334	*Nil.*	(*d*) 3,325	(*d*) 65,024	(*d*) 775,035	305	141,264	986,290	2,209,461
1910.	(*f*)	*Nil.*	2,059	199	(*d*) 5,030	(*d*) 55,770	(*d*) 558,634	301	137,173	759,166	1,938,429
1911.	(*f*)	*Nil.*	(*g*)2,457	*Nil.*	(*d*)2,177	(*d*)41,753	477,920	507	109,296	634,110	1,386,464
1912.	(*f*)	*Nil.*	(*g*)1,664	*Nil.*	(*d*) 1,332	(*d*) 48,618	816,984	1,567	104,670	974,835	1,982,000
1913.	(*f*)	*Nil.*	(*g*)4,048	*Nil.*	(*d*) 9,650	(*d*) 49,753	(*d*) 612,743	(*f*)	(*d*) 102,239	778,433	....
1914.	501	*Nil.*	1,724	410	1,970	39,881	402,754	1,222	100,198	548,660	....

(*a*) Statistics of 1900–1906 are by the U. S. Geological Survey. (*b*) Includes 1300 tons of manganiferous iron ore from Vermont. (*c*) As reported by Virginia Geological Survey. (*d*) As reported by U. S. Geological Survey. (*e*) Estimated. (*f*) Figures not available. (*g*) Includes Tennessee and California.

Although there is considerable activity at several mines in this country, and as a result there may be a markedly increased output, it is unlikely that domestic deposits will become a material factor in supplying our needs. Manufacturers of ferro-manganese, as well as of dry batteries and flint glass must continue to depend mainly upon foreign ore supplies. The shortage in high-grade ores for use in dry-battery and flint-glass manufacture has been keenly felt, and some plants have been compelled to close down.

By far the principal need of manganese in the United States is in the deoxidation of steel during refining; and with open-hearth capacity working to the limit, curtailment of ferro-manganese supplies had a serious aspect. A year ago two of the principal sources of manganese were cut off, with practically no high-grade manganese ore mined in this country, and with Brazil, a contributor of only 20 per cent. of the usual supply, remaining as the only other available source of raw material. An apparent deficiency in the supply of ferro-manganese, based upon proportion available to steel manufactured, has probably been offset by changed methods of practice. Spiegeleisen is proving an important substitute for ferro, and it is believed that other expedients have been adopted to lower consumption. Increased supplies of ore are to be expected from Brazil and Cuba, and these, coupled with domestic supplies and such shipments of ferro-manganese as are received from England, are thought to be sufficient to prevent a famine.

Imports of manganese ore into this country in 1915 have been larger than anticipated, the total for the year being 320,782 gross tons, compared with 283,294 tons in 1914, and 345,090 tons in 1913. About 90 per cent. of the ore came from Brazil in 1915. Imports of ore were particularly heavy in the last half year. A few small cargoes were received from Cuba. Receipts from the principal sources of supply have been as follows; figures for 1915 are estimated:[1]

	Brazil.	Russia.	India.
1905	114,670	24,650	101,030
1906	30,260	13,805	154,180
1907	52,922	1,000	95,300
1908	17,150	250	143,813
1909	35,600	14,486	145,140
1910	53,750	33,120	140,965
1911	41,600	19,103	106,580
1912	81,580	83,334	128,645
1913	70,200	124,337	141,587
1914	113,924	52,681	103,583
1915	290,000	....	30,000

Imports of ferro-manganese for 1915 were much below normal, due to the restriction imposed by Great Britain. Receipts for 1915 are reported as 55,263 gross tons, compared with 82,997 tons in 1914, and 128,070 tons in 1913. Average annual import for the period 1910–1914 was 100,793 gross tons. Importation in 1915 was only 585 tons in the first quarter, due to the British embargo; in the second and third quarters receipts were about 50 per cent. higher than in the last quarter of the year.

Domestic production was larger in 1915 than in any previous year. The total was 146,542 gross tons, exceeding that of 1912, the next highest year, by 21,164 tons. For the 5-year period 1910–1914, annual production averaged 99,363 tons.

Under normal conditions, about one-half of the requirement is imported, largely from England; the other half is made here chiefly from imported ores.

Statistics of United States production of ferro-manganese and spiegel-

[1] *Iron Age*, Jan. 27, 1916.

eisen, and our importation of manganese ore and ferro-alloys in recent years are listed below:

UNITED STATES PRODUCTION AND IMPORTS
(Long tons)

	Ore Imports.	Ferro-manganese.			Spiegeleisen.	
		Imports.	Av. Value per Ton. (*a*)	Production.	Imports.	Production.
1906	221,260	84,359	$58.72	55,520	103,267	244,980
1907	209,021	87,400	61.27	55,918	48,995	283,430
1908	178,203	44,624	41.70	40,642	4,579	111,376
1909	212,765	88,934	38.19	82,209	16,921	142,831
1910	242,348	114,228	37.99	71,376	25,383	153,055
1911	176,852	80,263	37.56	74,482	20,970	110,236
1912	300,661	99,137	39.41	125,378	1,015	96,346
1913	345,090	128,070	44.37	119,496	77	110,338
1914	283,294	82,997	41.33	106,083	2,870	79,935
1915	320,782	55,263	60.31	146,542	200	93,282

(*a*) At foreign port, no freight or duty.

Tonnage of ferro-manganese available for consumption, as represented by the sum of imports plus production, was 201,805 tons in 1915, 189,080 in 1914, and 247,566 tons in 1913. The smaller amount available in 1915, in view of the heavy output of open-hearth steel, was to a degree offset by the increased output of spiegeleisen. This material, ordinarily used solely in Bessemer practice, replaced some ferro-manganese in open-hearth steel-making.

Prior to 1915, practically the only steady producer of ferro-manganese in this country was the United States Steel Corporation. Its great annual needs warranted steady production to satisfy its own requirements. Foreign ore was used almost entirely. In 1915, Jones & Laughlin, the Maryland Steel Co., and the Colorado Fuel & Iron Co., all large independent interests, put furnaces upon the making of ferro-manganese, chiefly for their own needs. Two or three other companies engaged in the manufacture of ferro-manganese and spiegeleisen for the market, these being the American Manganese Mfg. Co., operating a blast furnace at Dunbar, Pa., the Noble Electric Steel Co., of San Francisco, and the Electro-Metallurgical Co., of Niagara Falls; the last two operating electric furnaces. The New Jersey Zinc Co., at Palmerton, Pa., has continued to be the leading domestic maker of spiegeleisen, using manganiferous zinc residuum. Demand and output in 1915 were very heavy, and late in the year arrangements were completed for operation of a blast furnace at Newport, Pa., to make spiegel from zinc residuum furnished by the New Jersey Zinc Co. The Steel Corporation has continued to be a producer of spiegeleisen at South Chicago and Ensley, but output has grown less yearly, because of the decline of the Bessemer process.[1]

[1] C. J. Stark, *Iron Tr. Rev.*, Jan. 6, 1916.

The ferro-manganese market was much affected by the peculiar conditions prevailing. Early in the year no alloy was being received, due to the British embargo. Negotiations were under way to lift this, but the conditions imposed by Great Britain were declined as too severe; a formal guarantee by each purchaser that ferro-manganese would not be re-exported to enemy countries, and that steel into which it entered would not reach these nations. Uncertainties in interpretations of the license agreement were finally cleared up, and in the latter part of February permits were granted for monthly shipments of 5000 tons of ferro-manganese to the United States. The first lot arrived about the first of April.

In the early part of the year, the price of 80 per cent. ferro-manganese was $68 seaboard, $30 above the market just before the outbreak of the war. Little import material was available and there was not a great deal of interest because of the dullness prevailing in the steel industry. With the continuance of the embargo, spot material became scarce, and some sales of domestic ferro were made at $100 Pittsburgh. In March a new price was made of $78 seaboard, for unguaranteed arrivals; spot material was sold at $90 to $100 in small lots. A further advance to $88, seaboard, was made at the last of April, and this was soon raised to $100 in the middle of May. This figure remained throughout the year as the nominal quotation, although sales were made at considerably higher prices for spot material and especially for small lots which were badly needed by steel producers to tide over a stringency. About Aug. 1 shipments, which had been fairly regular at 5000 tons per month, slumped off, due to an uneasiness in England regarding home supplies, and they were not resumed until October. The scarcity of ferro-manganese became rather acute, and some sales of small lots were made at $140 seaboard, the highest price since the Russo-Japanese war. Although steel-making was going on at a record pace in the last few months of 1915, resumption of imports of ferro from England, together with large receipts of ore from Brazil, served to hold the market steady.

Average monthly prices for ferro-manganese at eastern seaboard, based upon actual sales for the past 4 years, have been as follows:

	1912.	1913.	1914.	1915.
January	$41.00	$65.00	$36.00	$68.00
February	41.00	65.00	38.00	100.00
March	41.00	65.00	38.00	100.00
Gpril	43.50	65.00	38.00	100.00
May	47.50	61.00	38.00	100.00
June	48.00	61.00	37.50	105.00
July	49.50	58.50	27.50	103.00
August	52.00	56.00	100.00	105.00
September	55.00	55.00	80.00	110.00
October	59.00	50.00	66.00	105.00
November	61.00	50.00	68.00	100.00
December	65.00	45.00	68.00	100.00

Adjustments in practice to use spiegeleisen as a substitute for ferromanganese, resulted in a demand at increasing prices. At the beginning of the year 20 per cent. spiegel was at $25 furnace. In February it advanced to $26, and in September to $28 to $30 furnace, remaining thus for the rest of the year.

Abnormal ocean freights, coupled with curtailment of usual supplies, resulted in exceptional prices for manganese ore. Brazilian ore, since it offered a fairly certain supply unhampered by conditions as to use, was in great demand and was sold in much greater quantities than ever before in this country. Sales were made as high as 44 cts. per unit at Rio de Janeiro, equivalent to about 56 cts. at Atlantic ports in this country. A year before it was sold at 18 cts. at Philadelphia.

In the last half of 1914, the Carnegie Steel Co. announced the following schedule of prices for domestic ores, per gross ton delivered at Pittsburgh or South Chicago: 49 per cent. Mn, 25 cts. per unit; 46 to 49 per cent., 25 cts.; 43 to 46 per cent., 24 cts. The above prices are based upon ores of not more than 8 per cent. SiO_2 or 0.20 P, and are subject to penalties for excess, up to the rejection limits. The latter are 40 per cent. Mn, 12 per cent. SiO_2, and 0.225 P on dried samples. This schedule was maintained until September, 1915, when an advance of 19 cts. per unit was announced. The new rate is 45 cts. per unit for 49 per cent. ore.

Special railroad rates which had prevailed on imported ferro-manganese from Baltimore to inland points, were advanced in the latter part of the year to conform to the usual domestic rate on like commodities.

Production of manganese steel rails in 1915 was 3799 gross tons, almost entirely heavy sections of 100 lb. per yd. or over.

Mining.—The actual results, so far, accruing from the renewed interest in the managanese deposits of Virginia, due to the war market for the ore, have not been so satisfactory as was hoped for a year ago. There has been a great deal of negotiating and several attempts at financing, and engineers, ore buyers and investors have worn quite bare the trails in the best known manganese-bearing areas.

The Crimora mines properties at Elkton, one in Rye valley and several others have, however, received serious attention, and with good results as far as development has progressed. The Piedmont Manganese Co.'s mine, near Lynchburg, has been re-opened and promises soon to resume shipments. At Crimora the consummation of the very extensive equipment and financial program has delayed actual output. At Elkton litigation as to title has kept back recent negotiations. In Rye valley, financial mishaps in Philadelphia postponed the completion of what promised to be a successul operation to mine manganese and manganiferous iron ore. Numerous smaller operations have realized small shipments. On the whole, outside capital has not yet come to take the Virginia deposits very seriously, and local capital is not available ordinarily for even the prospecting of the many promising deposits in the Piedmont, James-Staunton River, and the southwest Virginia districts.[1]

Manganese mining in the south has not been successful, and for several years it has been at a low ebb. In the middle 80's Virginia was an important producer, but competition from the cheaper supplies from Russia, India and Brazil made business unprofitable. Until recently the Carnegie Steel Co. successfully operated the Crimora manganese mine in Virginia but the lease was not renewed because of excessive royalty demands. Over 300,000 tons of ore was taken out.

The southern manganese area extends from Maryland to northern Georgia, paralleling the Appalachian range. There are many deposits, large and small, in the zone. Only a few have been exploited at all, and hardly any have been systematically explored. The reserves are considered to be very large and of great potential importance. The ores are generally of commercial grade, or capable of economical benefication. The same skill and diligence applied to the mining of the manganese ores of the South that is employed in iron mining, should enable this industry to prosper and expand.

The Crimora Manganese Corporation has taken over the property at Crimora, Va., and is making extensive improvements in mining and milling equipment, to enable it to put out several thousand tons of washed ore per month.[2] Exploration work shows over 5,000,000 tons of ore yet remaining in the deposit, with a representative analysis of Mn 57, Fe 0.37, P 0.075, SiO_2 2.13. The completed plant will probably be the largest in the world for the treatment of manganese ores.

The Powell's Fort manganese property near Woodstock, Va., is being developed. The mine produced pyrolusite ore for many years, and it is now planned to develop the veins of manganese ore traversing the property.

About the middle of the year the Western Manganese Co. commenced refining manganese ore at Alameda, Cal. The ore is obtained from the Ladd mine in Alameda County, which produced considerable quantities of ore prior to 1902. The output of the works is manganese oxide of high purity, to meet the requirements of manufacture of electric batteries, glass, terra cotta, paint and chemicals.[3]

The Owl Head manganese mine, about 45 miles from Silver Lake, San Bernardino County, Cal., is producing about 200 tons of manganese ore per month. The output is hauled about 30 miles by tractor to the

[1] *Eng. Min. Jour.*, Dec. 11, 1915.
[2] *Iron Age*, Mar. 30, 1916.
[3] *Min. Sci. Press*, July 10, 1915.

railway. The marketed product carries 76.80 per cent. manganese dioxide, 0.022 phosphorus, 3.58 silica, and 1.12 per cent. ferric oxide. There is also a large reserve of ore of somewhat lower grade.[1]

A high-grade manganese ore deposit is being developed in San Miguel County, Colo. It is claimed that large shipments can be made of material with 85 per cent. MnO_2 and less than 1 per cent. of iron, such as has been imported from Turkey.[2]

The demand for manganese created a market for the manganiferous iron oxides of Colorado which are too low in silica to be used by the lead-smelting works. The material is being profitably disposed of to steel works.[3]

WORLD'S PRODUCTION OF MANGANESE ORE (*a*)
(In metric tons)

Year.	Austria-Hungary.	Belgium.	Bosnia (*b*)	Brazil (*d*)	Canada.	Chile (*d*)	Colombia.	Cuba.	France.	Germany.	Greece.	India.
1902	12,883	14,440	5,760	157,295	175	12,990	*Nil.*	40,048	12,536	49,812	14,960	160,311
1903	11,489	6,100	4,537	161,926	135	17,110	(*c*)	21,070	1,583	47,994	9,340	174,563
1904	15,460	485	1,114	208,260	123	2,324	(*c*)	33,152	11,254	52,886	8,549	152,601
1905	23,732	*Nil.*	4,129	224,377	22	1,323	(*c*)	(*d*) 8,096	6,751	51,463	8,171	250,788
1906	20,577	120	7,651	121,331	84	35	(*c*)	(*d*) 13,997	11,189	52,485	(*d*) 9,200	579,231
1907	24,954	2,100	7,000	236,778	1	(*c*)	(*c*)	30,486	18,200	74,683	10,000	916,770
1908	27,257	7,130	6,000	166,122	*Nil.*	1	(*c*)	1,492	15,865	67,692	10,750	685,135
1909	29,966	6,270	5,000	240,774	*Nil.*	(*c*)	(*c*)	2,976	9,378	77,177	5,374	654,974
1910	28,964	*Nil.*	4,000	253,953	*Nil.*	(*c*)	(*c*)	(*c*)	7,925	80,559	41	813,761
1911	15,954	*Nil.*	3,600	213,000	5	(*c*)	(*c*)	(*c*)	6,036	87,297	733	681,015
1912	12,471	*Nil.*	4,650	154,870	68	(*c*)	(*c*)	(*c*)	5,576	92,474	7,719	643,209
1913	16,540	*Nil.*	4,700	183,630	*Nil.*	(*c*)	(*c*)	(*c*)	7,732	330,797	(*f*) 556	828,088
1914	(*c*)	(*c*)	4,120	(*c*)	28	(*c*)	(*c*)	(*c*)	(*c*)	(*c*)	(*f*) 558	693,824
1915	(*c*)	(*c*)	(*c*)	(*c*)	47	(*c*)	(*c*)	(*c*)	(*c*)	(*c*)	(*c*)	(*c*)

Year.	Italy.	Japan.	New Zealand.	Portugal.	Queensland.	Russia.	Spain.	Sweden.	United Kingdom.	United States. (*e*)
1902..	2,477	10,844	*Nil.*	(*c*)	4,674	536,519	46,069	2,850	1,299	989,519
1903..	1,930	5,616	71	30	1,341	414,334	26,194	2,244	831	671,151
1904..	2,836	4,324	199	(*c*)	843	430,090	18,732	2,297	8,880	461,854
1905..	5,384	14,017	55	(*c*)	1,541	508,635	26,020	1,992	14,582	877,482
1906..	3,060	54,339	16	22	1,131	1,015,686	62,822	2,680	23,126	1,141,681
1907..	3,654	20,589	26	1,374	1,134	995,282	41,504	4,334	16,356	517,177
1908..	2,750	11,130	*Nil.*	....	1,403	362,303	16,945	4,616	6,409	650,559
1909..	4,700	8,708	6	....	613	574,938	7,827	5,212	2,812	1,002,939
1910..	4,200	11,120	5	....	805	(*d*)668,050	8,607	5,752	5,554	771,818
1911..	3,515	9,787	1	6	1,000	(*d*)584,000	5,607	5,377	5,067	644,678
1912 .	2,641	12,060	*Nil*	6	313	(*d*)766,000	19,936	5,101	4,237	991,082
1913..	1,622	2,313	*Nil*	(*c*)	27	1,171,000	21,594	4,001	5,480	791,407
1914..	1,649	16,875	*Nil*	(*c*)	6	737,300	(*c*)	(*c*)	3,496	557,804
1915..	(*c*)	(*c*)	(*c*)	(*c*)	203	(*c*)	(*c*)	(*c*)	(*c*)	(*c*)

(*a*) Official statistics. (*b*) Includes Herzegovina. (*c*) Statistics not available. (*d*) Exports (*e*) Includes manganiferous iron ore. (*f*) Sales; production *nil*.

The manganiferous iron ores of the Cuyuna range are attracting attention, and are being used in the manufacture of spiegeleisen and low-manganese ferro-alloy. The American Manganese Mfg. Co. has been using

[1] *Min. Sci. Press*, Apr. 15, 1916.
[2] *Met. Chem. Eng.*, July, 1915.
[3] *Eng. Min. Jour.*, Jan. 8, 1916.

ore from the Cuyuna Mille Lacs property in a blast furnace at Dunbar, Pa., which is turning out manganese for the general steel trade. Low-manganese ferro-alloys are made from a mixture of Cuyuna and Brazilian ore; 80 per cent. ferro is obtained if the furnace is burdened with all Brazilian ore.

The Cuyuna manganiferous iron ores are described by E. P. McCarty.[1] The ore-bodies of the north range are manganiferous, those of the south range are not. A small tonnage of low phosphorus-content, and of spiegel grade with about Fe 44, P 0.036, Mn 10, SiO_2 18. This ore runs into high-phosphorus material which has not given satisfactory results so far by ordinary washing and concentration methods. There is no ore of grade suitable for ferro-manganese manufacture. Of the estimate of over 9,000,000 tons of high-phosphorus manganiferous ore on the range, 3,500,000 tons is ore of 10 to 20 per cent. manganese-content. Only 100,000 tons is of highest manganese, 22 per cent.[2]

Manganese and manganiferous ores available in the United States are described.

Foreign Countries

Great Britain.—The British manganese situation has been dominated by the supplies of manganese ore, which during the first 8 months of 1915, were much below normal. Average imports to Sept. 1 were only 20,629 tons per month, but increased to 53,073 tons for the last 4 months. The average monthly import for the year was 31,444 tons in 1915, against 39,869 tons in 1914, and 50,931 tons in 1913.

Imports of manganese ore into Great Britain in 1915 were 377,324 gross tons, compared with 479,435 tons in 1914, and 601,176 tons in 1915.

On Dec. 17, Brazilian manganese ore of 50 per cent. grade was quoted in England at 97 cts. per unit, while Indian ore, 50 per cent., was 58 cts. for east coast delivery, and 57 cts., c.i.f. west coast. September quotations were 66 cts. per unit for Brazilian ore, and 40 and 38 cts. for Indian, for east and west coast deliveries.

British output of spiegeleisen and ferro-manganese in 1915 was 255,464 gross tons, or 24 per cent. less than in 1914, when it was 336,354 tons. In 1913 the output was 355,389 gross tons, and in 1912, 277,240 tons. The 1913 production was the largest since 1905. The product is made in the Middlesborough, Cumberland and North Wales districts.

Exports of ferro-manganese were 103,077 gross tons in 1915, 111,788 in 1914, and 178,919 in 1913. Of these amounts, the United States received 55,201, 82,217, and 128,070 tons in the respective years.

[1] *Eng. Min. Jour.*, Sept. 4, 1915.
[2] *Min. Amer.*, Jan. 8, 1916; *Min. Eng. World*, Sept. 11, 1915.

Not more than a few thousand tons of manganese ores are produced per year in the British Isles, and nearly the whole of this comes from the Lleyn peninsula in Carnarvon, Wales. In earlier days, ore was mined in Devon and Cornwall, and the deposits are not exhausted, though at present prices they can not be worked at a profit; the chief deposits are found near Launceston in north Cornwall and at Brentor in western Devon. The vast resources of the Caucasus, Brazil, and India have quite eclipsed the British deposits, both as regards extent and metallic content. The chief ores in the west of England are pyrolusite and rhodonite, and rhodochrosite predominates in Wales. In Carnarvon, the Nant, Benallt, and Rhiw mines are in the hands of the North Wales Iron and Manganese Co., of Liverpool. At Nant, the undecomposed ore contains manganese in the form of carbonate with a small proportion of silicate, and at the outcrop as hydrated black oxide. It occurs as a bed from 10 to 20 ft. thick in the Lingula flags and shales of the Ordovician age. The ore at these mines averages 30 to 36 per cent. manganese, 7 to 10 per cent. iron, 18 per cent. silica, and 0.3 to 0.5 per cent. phosphorus. At the present time only the Nant mine is being worked, and the output is 4000 tons per year.[1]

India.—Exports of manganese ore from India in 1915 were 402,694 gross tons, compared with 537,960 tons in 1914. For 11 months of the fiscal year, April, 1915, to February, 1916, 444,289 tons were exported, of which 358,794 tons went to Great Britain. Distribution for recent years is noted below, being for the fiscal years ending Mar. 31; figures for 1915 are for 9 months only:

Year ended Mar. 31.	1914, Tons.	1915, Tons.	Apr. to Dec., 1915.
United Kingdom	258,776	227,281	295,567
Germany	18,950	14,250	....
Holland	8,200	....	....
Belgium	187,821	66,043	....
France	103,847	46,326	4,500
Italy	7,800	....	19,850
Austria	10,310	4,030	....
Japan	16,018	9,157	3,346
United States	106,377	73,503	35,000
Total	718,049	440,590	358,263

The Geological Survey of India reports a manganese ore putput for 1914 of 682,898 tons, compared with 815,047 tons in 1913. Maximum output was in 1907, when 902,921 tons was produced. The greater proportion is mined in the Central Provinces.

Russia.—The Russian manganese industry has been hard hit by the war, and production has been only 5 to 10 per cent. of normal. The

[1] *Min. Mag.*, Mar., 1916.

principal deposits are in the Caucasus, about 110 miles from the Black Sea. Almost all of a normal annual output of 1,000,000 tons was exported through the Dardanelles, and the closing of this passage prevented shipments and virtually checked operations.

Statistics for 1915 are not available. In 1914, exports of manganese ore were 737,300 metric tons, compared with 1,171,000 tons in 1913. Practically all of the shipments were made in the first 9 months of the year, and ceased when Turkey took part in the war and closed the Dardenelles.

Distribution of tonnage from the Chiatouri region were as follows for the years 1911 to 1914:

DISTRIBUTION OF CHIATOURI ORES

	1911.	1912.	1913.	1914.
Germany	295,000	322,500	412,000	326,403
Austria	40,600	40,000	25,400	32,435
Belgium	66,100	193,500	182,500	154,467
France	42,000	42,200	55,100	23,951
Great Britain	125,900	202,000	246,500	107,030
Italy	3,900	....	7,400	....
United States	16,100	96,300	137,700	34,548
Foreign	589,600	896,500	1,066,600	678,834
Russia	24,100	17,000	10,000	15,096

The quantity of ore put on the market in 1914 was 704,080 tons, of which 98 per cent. was exported.[1] At the close of the year the stock of ore on hand in the Caucasus district is estimated at 1,600,000 tons. The Chiatouri deposits are well situated for cheap production and export. Reserves are estimated at 100,000,000 tons. Mining is done in a crude, wasteful and expensive way on a small scale, and there is room for improvement in mining, milling and transport. The Caucasus region from 1904 to 1913 had an average annual output of 680,730 tons, or 75 per cent. of the Russian product. The Nikipol district yielded 195,010 tons per year, or 24 per cent. of the total. Other small producing districts are the Ural and West Siberia.[2]

Attention has been given recently to the Gainsinsk district, in the province of Podolia. There is a large supply of pyrolusite favorably situated for shipment. Odessa is 221 miles distant by rail. Mining at present is only in the exploratory stage, and production has not exceeded 450 tons, which has been sent to South Russian works.

Brazil (By Joseph T. Singewald, Jr. and Benjamin LeRoy Miller).—

The production of manganese in Brazil in 1915 was about 350,000 tons which exceeds all previous figures. The outputs of British India and Russia have greatly decreased since the outbreak of the war, so that there

[1] *Eng. Min. Jour.*, Jan. 8, 1916.
[2] *Eng. Min. Jour.*, May 20, 1916.

has been an increasing demand for Brazilian ores, especially in the United States. In 1913, one-fifth of our imports came from Brazil, whereas in 1915, that country furnished nine-tenths. Practically the entire Brazilian manganese output comes from the southern part of the State of Minas Geraes from mines along the Estrada da Ferra Central do Brazil. It consists of very high-grade ore averaging about 50 per cent. manganese, only 1 to 2 per cent. silica, and low in phosphorus. These deposits were described in some detail by the writers in *Iron Age*, Feb. 17, 1916.

There are two types of deposits in the region occurring in two separate areas known as the Miguel-Burnier district and the Queluz district respectively. The Miguel-Burnier district extends as a narrow belt 10 miles long parallel to the Ouro Preto branch of the railroad, and centers about the station Miguel-Burnier, 496 km. north of Rio de Janeiro. It lies at the southern edge of the great iron-ore region of Minas. The Queluz district lies to the south and centers about Queluz or Lafayette, a station 463 km. from Rio de Janeiro.

The Miguel-Burnier manganese ores occur in the Itabira iron formation which is a sedimentray series of probable Algonkian age and is the same formation that includes the great Brazilian iron-ore deposits. They occur in the form of bedded deposits of limited extent and a width of a few meters. There is some difference of opinion as to their relations to this series of rocks; according to one view they represent replacements of some of the numerous intercalated lenses of limestone, but according to another, they are regarded as syngenetic deposits forming an integral part of the sedimentary series in the same manner as the iron ores.

Of much greater importance as a producer is the Queluz district. The deposits in this district occur as elongated masses of more or less lenticular shape in an area of supposed Archean rocks consisting of granites, gneisses and schists. The ores are surface alterations of an original manganese rock known as queluzite, of which the most common and characteristic constituents are the manganese garnet spessartite, tephroite which is the manganese equivalent of olivine, and more or less manganese carbonate. Rhodonite is conspicuous locally and one phase of the rock consists of garnet and quartz. There is considerable doubt as to the exact nature of the queluzite; some look upon it as an igneous rock, and others as the product of contact metamorphism of lenses of manganese carbonate intercalated in the schists. The largest of the mines is the Morro da Mina, which in 1915 produced 200,000 tons, has produced a total of over 1,000,000 tons and has an estimated ore reserve of 10,000,000 tons. This is probably the largest deposit of high-grade manganese ore in the world. Mining is mostly by opencut and by hand. Costs in

1914 were 60 cts. per ton. Freight to Rio de Janiero is $1.50 per ton and from there to the United States $5 per ton. About 500 men are employed who are well treated by the company. All ore is passed over a 2-cm. screen, the oversize being shipped. The undersize, about 15 per cent. of the total, containing 35 per cent. manganese, is stored for future washing or other treatment.

Manganese ore exports from Brazil in the last three years, and their destination, are given as follows by U. S. Consul A. I. M. Gottschalk, Rio de Janeiro. The figures are, in metric tons:

Exported to	1913.	1914.	1915.
United States	39,400	87,630	266,877
Great Britain	16,800	23,500	10,100
Germany	5,000	....	....
Belgium	11,800	10,600	....
France	....	11,400	....
Total exported	122,300	183,630	288,671

Germany.—A Belgian engineer writes that at the beginning of the war most German steel works had a reserve of manganese supplies sufficient to last for 10 months with the reduced rate of production.[1]

The invasion of Belgium and Northern France, with their important war industries, and the capture of Antwerp gave to the Germans the ore stocks of that region. All the manganese ores were confiscated by the military authorities and carefully shipped to the Westphalia district under supervision of a technical commission. In the Spring of 1915 the Seigen and Nassau mines, which before the war were not worth working on account of the low percentage of manganese (15 to 20 per cent.), the high cost of mining and the competition of imported ores, were pushed to the highest production possible to meet the demand. Substitutes for manganese ore were looked for and found. The most important was the slag of the ferro-manganese blast furnaces of Westphalia, worthless before the war. The blast-furnace process involves a large loss of manganese in the slag. This slag, with 8 to 14 per cent. of manganese, is a fair ore under present conditions, with low mining costs and good fluxing qualities for basic pig irons; the chief drawback is high coke consumption. The writer's opinion is that Germany will not face a serious situation in manganese before the Spring of 1917.

The manganiferous ore of Sieguland, heretofore neglected in favor of foreign ores, has been turned to in the present shortage. There has been considerable handicap in production because of scarcity of explosives and raw materials and adequate transportation facilities. Also, it was necessary to supply the deficit in labor with prisoners of war.

[1] *Iron Age.*, Apr. 27, 1916.

The total output of the district in 1915 was 2,260,031 tons, and most of it was sold and used in the manufacture of spiegeleisen, about half locally and the rest in furnaces in Westphalia and Upper Silesia.

Vague hints have been passed from time to time regarding Germany's "metallurgical secret," whereby the works were to get along with less manganese because of the discovery of a substitute. It is said that calcium and magnesium are being used as deoxidizers. However, it must be remembered that in the year preceding the war Germany imported twice the ordinary amount of manganese ore from Russia and India. With steel outputs at two-thirds normal, and heavy reserves of ore, ferro, and spiegel, together with utilization of domestic supplies and the use of substitites wherever possible, some time must elapse before the ferro-manganses situation becomes acute.

The extent to which Germany has been dependent upon foreign supplies of manganese ores, is shown in the following table of imports for several years:

	Tons.		Tons.
1903	223,709	1908	334,133
1904	255,760	1909	384,445
1905	262,311	1910	487,872
1906	331,171	1911	420,709
1907	393,327	1912	523,132

In 1912 Russia furnished 336,819 tons, India 126,614, Spain 30,707, and Brazil 20,857 tons.

Other Countries.—Spain exported 9136 metric tons of manganese ore in 1915 against 8965 in 1914 and 27,793 tons in 1913. In 1907 exports were 67,996 tons, but since that year they have steadily declined.

Japan produced 16,875 metric tons of manganese ore in 1914.

A large deposit of high-grade ore is reported in South Australia, about 75 miles from Port Augusta. Queensland production of ore was 200 tons in 1915, and 6 tons in 1914.

Italy produced 1649 metric tons of ore in 1914.

The Cauto Mining Co., a Rogers-Brown interest in Cuba, shipped about 6000 tons of manganese ore in 1915.

Recently an American syndicate opened a manganese mine at Madinga, on the Gulf of San Blas, in the Province of Colon, about 70 miles east of the city of Colon. A trial shipment of some 900 tons of the ore has just been made to New York. One of the owners, who acts as agent for the syndicate, states that shipments of 1500 tons a month can probably be made for several months if vessels are available for that purpose; but beyond that nothing definite can now be stated regarding the development of the mine. A wharf at deep water has, however, been built near the mine, and if the supply of ore holds out and it can be profitably marketed it is the purpose of the owners to develop the Madinga mines to a considerable extent.[1]

[1] *Comm. Rept.*, Mar. 1, 1916.

Technology

Stringency in ferro-manganese supplies has resulted in some modifications in steel-making practice.[1] Spiegeleisen, with 20 per cent. manganese, is being used extensively in conjunction with ferro as a partial substitute. It is also reported that some of the spiegel has been converted by re-smelting into a higher manganese, low-carbon alloy for use in open-hearth steel-making.

Partial deoxidation of the steel by 50 per cent. ferro-silicon reduces the quantity of ferro-manganese needed; but the use of ferro-silicon to entirely replace the manganese has not proved successful, although the relative heats of reaction of silicon and manganese with oxygen or iron oxide would lead to the supposition that the silicon should be the more active and effective agent.

Ferro-titanium has been adopted, especially in steel foundries. It is reported calcium and magnesium have been extensively used in Germany as a substitute for ferro-manganese. In the exigencies of the situation prevailing in that country, no doubt these two metals are of value; but their necessarily high cost should prevent extensive application in countries where manganese is available, even at abnormal prices.

The manufacture and properties of manganese steel castings are discussed by W. S. McKee.[2] About 60,000 tons per year are now made and used where toughness and strength in combination with resistance to wear are wanted. Manganese steel is now employed extensively in rolling-mill machinery, conveyor chains and buckets, screens, pulverizing hammers and crushing-machinery parts, dredge and shovel buckets, steel rails, and railway track work at crossing points, etc. The manganese-content is from 11 to 13.5 per cent., and the carbon from 1 to 1.3 per cent. The steel is toughened by heating and quenching in water. Physical properties and metallographic features are described and illustrated.

G. Rumelin and K. Fick[3] have investigated the iron-manganese system. Melts with over 13 per cent. of manganese solidify direct to a continuous series of mixed crystals of manganese and gamma iron. The A_3 and A_2 points can be detected for alloys containing from 0 to 50 per cent. of manganese.

H. M. Howe and A. G. Levy[4] have investigated the question as to whether the deformation lines in manganese steel are twins or slip bands, and report that the evidence is in favor of the latter. The research has an important bearing not alone because it throws light upon the iron-manganese relations, but also in its application to the causes of hardening in steel.

[1] *Iron Age*, June 15, 1916.
[2] *Iron Tr. Rev.*, Dec. 2, 1915.
[3] *Ferrum*, vol. **12**, 1914–1915.
[4] *Bull. Amer. Inst. Min. Eng.*, Mar., 1915.

The use of the Wile electric furnace in the manufacture of ferro-manganese is discussed.[1] The furnace is of the three-phase type, with one bottom and two top electrodes. In making 80 per cent. ferro-manganese the average power consumption is 800 kw.-hr. per ton.

Investigation of the properties of manganese steel as influenced by heat treatment, has been conducted by R. R. Abbott.[2]

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MICA

By J. Volney Lewis

The Mica Minerals

Varieties.—Of the many kinds of mica known to the mineralogist only two are found in the mica markets of the world. Muscovite, also known as "white" mica and potash mica, furnishes by far the greater part of the mica of commerce. Chemically it is a silicate of potassium and aluminium. In thin sheets it is commonly colorless or nearly so, but in thicknesses of $\frac{1}{16}$ in. or more it shows various shades of gray, green, yellowish brown ("rum"), and dark red ("ruby"). Red, yellow, or black stains of iron oxides prevent the use of the sheets for stoves and depress the price accordingly.

Phlogopite, the other commercial variety of mica, usually has a light yellowish-brown color and hence is known as "amber" mica. It is a silicate of potassium, magnesium, and aluminium and is sometimes called magnesia mica. Canada is the chief source of this variety.

Properties and Uses.—The most extensive uses of mica, those of the electrical industries, depend upon its perfect cleavage, its non-conductivity of electricity, its non-inflammability, and to a less degree upon its flexibility and elasticity. Sheets of many sizes and shapes, discs, washers, rings, tubes, mica-covered cloth and tape, smaller sheets and scrap mica cemented into sheets and boards of any desired size and thickness, ground mica molded with shellac or other cement into insulators of many forms—these are some of the common materials that have become indispensable in a wide range of electrical apparatus, machinery, fixtures, and wiring. For many of these applications there is no substitute.

Add to the above qualities softness and the reason is found for the specific demand for "amber" mica (phlogopite), which is a little softer than the common or "white" mica, and for this reason is more in demand for use between the commutator segments of motors and dynamos, where it is desirable that the insulation shall wear away at the same rate as the metal in order to avoid sparking.

Flexibility, transparency, and resistance to a high degree of heat determine the applications of mica in stove doors, lamp chimneys, and lamp shades. The earlier demand for mica was chiefly for use in stoves and a considerable amount is still so used, since no satisfactory substitute for it has been found. The clearest mica, free from specks, stains, or objectionable color, is demanded for this purpose, and the grades suitable for this trade command the highest prices.

The brilliant luster of the cleavage faces, even on the minute particles of the finest powder, admirably adapts ground mica to wallpaper decoration and the manufacture of fancy paints. Flakes and powders of various metals can also be used for these purposes, but only at much greater cost. The luster also plays an important rôle when the coarser "bran" mica is used with grains of darker minerals in concrete facing to imitate natural stone finish. Perfect cleavage combined with softness gives the powder also a great lubricating value. Mixed with oil or grease it serves a purpose similar to powdered talc or graphite in lubricants. Coarser flakes are also spread over tarred roofing paper to prevent it from sticking when rolled up. Like the powder of several other minerals, ground mica finds some use in rubber, partly as an adulterant and partly for some valuable quality desired in the rubber. Its non-conductivity of heat also adapts it to the manufacture of coverings for steam pipes and boilers to prevent the loss of heat.

Mica Mining

History.[1]—Mica mining in the United States commenced in 1803 with the opening of the Ruggles mine in Grafton County, N. H., and until 1867 this state produced all the mica mined in this country. Mica was discovered in North Carolina about this time and successful mining was quickly established. Soon afterward mines were also opened in Virginia and several other eastern States, and in the early eighties production was begun in South Dakota, New Mexico, and Idaho, followed in the later eighties and the nineties by Colorado and other western States.

Until about 1890 the bulk of the mica was used in the glazing trade, for which only the large sizes and clear sheets were considered suitable. The great growth of the electrical industries in the nineties, the use of smaller sheets in stoves, and the demand for ground mica for wallpaper decoration brought into the market much of what had formerly been waste.

Sources.—Most of the mica in the markets of the world continues to be drawn from British India, Canada, and the United States, although important contributions come from Brazil, German East Africa, and now from China. Promising deposits of good mica are known and mined in a small irregular way in several other countries, but their total output from year to year is generally insignificant. In the United States mica

[1] D. B. Sterrett, *Min. Res. of U. S.*, 1914, II, pp. 68–73.

deposits are known in more than 20 of the States, but only half of these have produced important amounts. The following States, named in the order of the value of their output, reported production to the United States Geological Survey for 1914: North Carolina, New Hampshire, Idaho, Virginia, South Dakota, New Mexico, Colorado, Alabama, South Carolina, Maryland, Connecticut, Georgia, and Maine. The last four had produced none in 1913, and Pennsylvania and New York, which had produced mica in 1913, reported none for 1914.

Many good deposits are known in this country and under the stimulus of strong demand the production is increasing. While imports for many years have averaged considerably more than domestic production, the mines are undoubtedly capable of fully meeting the demand, with the possible exception of the softer amber mica, which is not now mined in any of the States. It is even possible that at least a part of this market could be supplied from the New Jersey deposits, to which attention is directed in another paragraph. There is also a considerable quantity of mica still available in the waste dumps of the old mines, especially in New Hampshire, and the dumps yet to be worked over are large.

Statistics of Mica in the United States

Domestic Production.—The value of mica produced in the United States in 1914, as reported to the U. S. Geological Survey, was $328,746, which was $107,314 less than in the preceding year. North Carolina continued to lead, as for many years past, with a value of $195,270, and New Hampshire was second, with $47,837. The value of production in Virginia was $25,653. Following the general depression that accompanied the opening of the war there was renewed demand and increased activity in mining during the year 1915. The returns, when available, will undoubtedly show a considerable increase over the preceding year.

PRODUCTION OF MICA IN THE UNITED STATES, 1905–1915 [1]

	Sheet Mica.		Scrap Mica.		Total Value.	Value of Imports.
	Pounds.	Value.	Short Tons.	Value.		
1905	924,875	$160,732	1,126	$17,856	$178,588	$403,756
1906	1,423,100	252,248	1,489	22,742	274,990	1,042,608
1907	1,060,182	349,311	3,025	42,800	392,111	925,259
1908	972,964	234,021	2,417	33,904	267,925	266,058
1909	1,809,582	234,482	4,090	46,047	280,529	618,813
1910	2,476,190	283,832	4,065	53,265	337,097	725,823[2]
1911	1,887,201	310,257	3,512	45,550	355,804	505,552[2]
1912	845,483	282,823	3,226	49,073	331,896	755,584[2]
1913	1,700,677	353,517	5,322	82,543	436,060	947,780[3]
1914	556,933	277,330	3,730	51,416	328,746	629,484[3]
1915	....	....	....	....	....	692,209[3]

[1] U. S. Geol. Surv.
[2] Imports include the value of ground mica, first reported in 1910.
[3] Statistics from the Department of Commerce.

Imports.—The ratio of imports to domestic mica has varied considerably from year to year, with the imports generally in excess. For the 11-year period, 1904–1914, imports of sheet mica exceeded domestic production by more than 33 per cent. in quantity and 149 per cent. in value. Incidentally this comparison shows very clearly the effect of the varied tariff laws in excluding the cheaper grades.

The imports are set forth in detail in the table below. There was an increase in total value for 1915 of 10.1 per cent. The increase was far greater, however, in imports of manufactured mica—21.6 per cent. in quantity and 42.6 per cent. in value. The average price of the same class of mica in 1914 was 47.2 cts. per lb.; in 1915 not only was the amount much larger but the average price was 55.4 cts. per lb. There was also an advance in the average value of ground mica imported—1.12 cts. per lb. in 1915, as against a little less than 1.01 cts. in 1914—but the falling off in amount more than counterbalanced the higher value per pound, and the total value of ground mica imported was a little less than in the preceding year. There was also a slight falling off in the total value of cut mica imported. The net gain in total value of imports, in spite of the loss in these two classes, was due to the great increase in both quantity and value of the uncut mica.

IMPORTS OF MICA INTO THE UNITED STATES, 1906–1915[1]

	Unmanufactured.		Cut or Trimmed.		Ground.		Total.
	Pounds.	Value.	Pounds.	Value.	Pounds.	Value.	Value.
1906	2,984,719	$983,981	82,019	$57,627	....	....	$1,042,608
1907	2,226,460	848,098	112,230	77,161	....	....	925,259
1908	497,332	224,456	51,041	41,602	....	....	266,058
1909	1,678,482	533,218	168,169	85,595	....	....	618,813
1910	1,424,618	460,604	536,005	263,831	....	$1,298	725,823
1911	1,087,644	346,477	241,124	155,686	....	3,389	505,552
1912	1,900,500	649,236	88,632	99,737	....	6,611	755,584
1913	2,047,571	751,091	46,336[2]	191,924	290,757	4,765	947,780
1914	356,888	168,591	........[3]	456,805	404,840	4,088	629,484
1915	433,822	240,389	....	447,962	344,040	3,858	692,209

[1] Statistics 1905–1912 from U. S. Geol. Survey, others from Bureau of Foreign and Domestic Commerce.
[2] From Jan. 1 to Oct. 3.
[3] Quantities not reported.

More than half of the cut mica and two-thirds of the untrimmed mineral were imported in the second half of the year, as shown in the following table, compiled from the reports of the Bureau of Foreign and Domestic Commerce.

IMPORTS OF MICA INTO THE UNITED STATES IN 1915

	First Half-year.	Second Half-year.	Total Quantity.	Total Value.	Value per Pound.
Cut or manufactured	$204,584	$243,378	....	$447,962	....
Unmanufactured	Pounds.	Pounds.	Pounds.	Value.	....
Not over 15 cts. lb.	29,165	120,559	149,724	$14,214	9.5¢
Over 15 cts. lb.	119,928	164,170	284,098	226,175	79.6¢
Total unmanufactured	149,093	284,729	433,822	240,389	55.4¢
Unmanufactured, 1914	....	....	356,888	168,591	47.2¢
Increase, 1915	....	....	21.6%	42.6%	18.8%

Exports.—Exports of manufactured mica in 1915 went chiefly to Canada, France, Mexico, and England; unmanufactured chiefly to England, Canada, and Germany. The following statistics, from the Bureau of Foreign and Domestic Commerce, are for fiscal years, ending June 30.

EXPORTS OF MICA FROM THE UNITED STATES, 1910–1915[1]

	Unmanufactured.		Manufactured Value.	Total Value.
	Pounds.	Value.		
1911	415,862	$15,649	$20,267	$35,916
1912	356,601	14,936	25,876	40,812
1913	298,711	14,175	48,009	62,184
1914	433,329	25,962	39,140	65,102
1915	214,371	5,019	24,336	29,355

Market Conditions.—During a part of the year 1915 the demoralizing effects of the early months of the European war were still felt in the mica trade and stocks on hand are reported to have been more than sufficient to meet demands. With the recovery of commercial activity and the cutting off of much of the foreign mica, so that supplies were difficult to get with any regularity, buyers turned to the domestic product. A fair demand followed, running to all grades and sizes, with a tendency toward higher prices, but not abnormal. The demand has continued strong and has led to considerable increase in mining in this country. In some quarters a fear is expressed that at the termination of the war reserved stocks of mica that are supposed to have accumulated in India will be suddenly released, so that the market may again become overstocked.

Value of Fine-split Amber Mica.[1]—The price of fine-split amber mica, size 1 by 2, exported largely from the Ottawa district, Can., and invoiced at 20 to 35 cts. per lb., is considered very low when the following facts are taken into consideration: Market value per pound of rough amber mica, 1 by 2, 12 cts.; waste on 1 lb. of fine amber mica, 4 cts.; freight and hand-

[1] *Comm. Rep.*, Oct. 9, 1915, p. 138.

ling from mine to factory, ½ ct.; profit, 8 cts.; total, 36½ cts. Most of the Ontario mica is sent to Ottawa to be trimmed and prepared for the American market. The fine-split amber mica is invoiced at Kingston at 33 to 38 cts. per lb. Charges have been made that the Ottawa manufacturers have purposely cut prices in order to secure the American trade. Mica shipments enter the United States at points in the states of Vermont and New York, where duty is paid, and are afterward forwarded to their destination.

New Jersey.[1]—Mica was mined at several places in New Jersey 25 to 50 years ago. Some of the deposits are now receiving renewed attention that may lead to a revival of the industry. The mineral at all of the mines is phlogopite, or amber mica, although the colors are hardly those suggested by the name amber, ranging from gray to brownish, and in some of the old reports the mineral was referred to as muscovite. Under the old conditions it was considered inferior on account of its color, and considerable quantities of small sizes and dark-colored sheets of larger size were thrown into the waste. Recently some of this has been recovered from one of the old dumps and sold, and steps are said to have been taken to test some of the workings with a view to their possible operation again.

Two localities in Morris County and two in Warren were the chief places worked in a small way in former years. The Morris County localities are (1) 4 miles west of Morristown, near the Mendham road, and (2) 1 mile south of Mendham; those of Warren County are (1) 3½ miles west of Washington and 1 mile north of Broadway, on the south slope of Scotts Mountain, and (2) 6 miles northeast of Phillipsburg and 3 miles north of Stewartsville. Contrary to the usual mode of occurrence of commercial deposits of phlogopite, these are all in pegmatite, which is commonly the mica-bearing rock of muscovite, or white mica. These pegmatites are intruded into the gneisses of the Highlands. In this respect the amber mica of New Jersey is in marked contrast with the well-known deposits of Canada, in which the phlogopite is associated with calcite and apatite, forming veins and irregular pockety deposits in dike-like bodies of green pyroxenite.

North Carolina.[2]—From partial returns it appears that North Carolina will show a considerable increase in the production of mica in 1915 as compared with 1914, or indeed with any previous year. The production of cut mica for electrical purposes has increased more than any other kind, this form of mica more than doubling the values of the sheet, ground and scrap mica combined. It is estimated that the total value of the mica from North Carolina in 1915 will be about $300,000.

[1] *Press Bulletin*, Division of Geol., Dept. of Conservation and Development, State of N. J., Feb., 1916.
[2] Information furnished by Dr. J. H. Pratt, State Geologist.

Mica in Foreign Countries

Canada.—The total value of mica produced in Canada in 1915 was $81,021 as compared with $102,315 in 1914. As in former years, the greater part of this was exported to the United States.

Statistics of mica production and exports are given in the accompanying table. Production represents the quantities and values as reported by the mine operators. The exports on the other hand, represent material that has been through the mica mills, and has been cut, split, trimmed, or manufactured. Stocks are frequently accumulated, so that it is not possible to draw comparisons between the records.

The production in Quebec amounted to 427,326 lb., valued at $50,035, and in Ontario, to 137,090 lb., valued at $30,957.

STATISTICS OF MICA IN CANADA, 1910–1915

	Production,[1] Value.	Exports.[1]		Exports to U. S.[2]			
		Pounds.	Value.	Pounds.	Value.	Cut Mica.[3]	Total Value.
1910	$190,385	937,263	$330,903	867,489	$333,196	....	333,196
1911	128,677	693,940	242,548	632,091	239,964	....	239,964
1912	143,796	895,338	334,054	724,849	213,750	....	213,750
1913	194,304	817,152	240,775	1,277,252	218,365	....	218,365
1914	102,315	669,163	178,940	679,215	124,785	42,471	167,256
1915	80,992	879,631	236,124	507,922	69,481	136,700	206,181

[1] Canadian Dept. of Mines.
[2] Years ending June 30.
[3] Value reported separately, without quantity, after Oct. 3, 1913.

India in 1914.[1]—From the report of the Chief Inspector of Mines in India for 1914 it appears that four mica mines in the Nellore district in Madras were relinquished and 40 were suspended. The output during the last 5 months of the year was only 70,000 lb., as compared with 470,000 lb. in the first 7 months. The total output for all of India was 3,818,900 lb. as compared with 4,336,000 in 1913, a decrease of 12.51 per cent. and the first decrease since 1910.

The trade suffered severely from the beginning of the war and the output fell away in consequence. A large proportion of the demand for mica had hitherto come from Germany for use in the electrical industries. It is stated that certain firms with German interests, which were large purchasers of mica, have closed down. The export of mica to other countries in Europe was practically cut off and the industry generally was much hampered by the abnormally high rates for ocean freights and insurance brought about by the war. There was also considerable difficulty with regard to shipments to America, to which country large consignments are sent direct in normal times.

[1] *Comm. Rep.*, Oct. 26, 1915, p. 380.

Transvaal.[1]—The Oliphants River mica belt, east of Leydsdorp and about 200 miles from Delagoa Bay, is undergoing further development since the completion of the railroad to Leydsdorp furnishes accessible transportation facilities. The country is an undulating, thickly wooded bushveld in which the mica-bearing rocks strike east and west. The mineral is muscovite and is found in pegmatite masses which intrude irregularly the older gneisses and schists. The outcrops are easily followed and prospecting has been undertaken by many syndicates and individuals. Owing to the undulating nature of the country quarrying can be carried on from the hillsides and underground mining will be unnecessary. The ground is nearly all government land, large areas having been allowed to lapse by prospectors who had pegged for purposes of speculation. Promising deposits have been found over a distance of 60 miles east and west, and some preliminary shipments to London have yielded favorable results.

West China.[2]—Mica which seems to be of very good quality is found near Sungpan, in the Szechwan Province, and one of the large Chinese firms at Chunking, with a branch office in Shanghai, is prepared to export the product. The price, delivered at Shanghai, is between 9 and 10 cts., U. S. currency, per lb. About 15,000 lb. can be delivered every year.

Bibliography

For important recent publications on mica reference should be made to the bibliography printed in this place last year. No publications of comparable value have appeared in the meantime.

[1] *So. Afr. Min. Jour.*, Dec. 11, 1915, pp. 343, 344, and Jan. 22, 1916, p. 485.
[2] *Comm. Rep.*, June 26, 1915, p. 1401.

MOLYBDENUM

By James Aston

Owing to the great demand for molybdenum, which began a little before the European war, there has been an active search for molybdenum minerals of which only two, molybdenite, the sulphide, and wulfenite, the lead molybdate, have been found in commercially valuable quantity. In the first half of 1915 the Primos Chemical Co. began producing molybdenite concentrates from a mine near Empire, Colo. This is the first American mine to be extensively operated for molybdenite though there have been many lesser attempts at mining the mineral.[1]

During 1915 inquiry for molybdenum products dropped to practically nothing, the sudden demand of the last quarter of 1914 proving to be only temporary interest. That demand, however, caused molybdenum to be prospected for as never before with the natural result that molybdenum ores are offered very freely with practically no demand at present. [2]

The Primos Chemical Co. shut down the Empire operation in Colorado on Sept. 1 due to a stock of ore in Pennsylvania large enough to last for a long time at the present rate of consumption. Efforts to broaden the use of molybdenum to at least what it was from 1900 to 1905 have thus far failed. What the future will bring depends a good deal upon experiments in progress.

At the close of 1915 there was no demand for molybdenum ores amounting to any tonnage and low-grade ores such as were bought in 1914 were not taken, due to a large supply of high-grade ore on the market.

Molybdenite of high grade commanded as high as $2 per lb. just after the outbreak of the European war but quieted down in the latter part of 1914. At the close of 1915 it was quoted at $1.50 per lb. for material with 80 to 90 per cent. of MoS_2. A few years ago the price of high-grade molybdenite was from 15 to 30 cts. per lb.

It is said that molybdenum deposits occur in practically in every mining county in Colorado, but so far, with one or two exceptions, they are undeveloped and unexplored. In some cases molybdenum is associated with copper. Some of the crude ores range from 1 to 2 per cent. of molybdenum-content.

In the latter part of 1915 small quantities of molybdenite were mined in one or two localities of California, but the ore was not marketed.

[1] *U. S. Geol. Surv. Press Bull.*, July 1, 1915.
[2] *Eng. Min. Jour.*, Jan. 8, 1916.

The American Molybdenum Co., Deluge Wash, Mohave County, Ariz., has erected a 5-ton mill to treat molybdenum ores. The concentrate will be shipped to Los Angeles for reduction to ferro-molybdenum. The company has molybdenite ore on the property. In addition there are several holdings of high-grade ore in the vicinity, and 150 men are at work in the district.[1]

The principal consumers of molybdenite in the United States are the Primos Chemical Co., Primos, Pa., York Metal and Alloys Co., York, Pa., and the Goldschmidt Thermit Co., New York City; all of these make molybdenum metal or ferro-molybdenum. Others are: J. T. Baker Chemical Co., Phillipsburg, N. J., Baker and Adamson Chemical Co., Easton, Pa.; Foote Mineral Co., Philadelphia, Pa., S. Schaaf-Regelman, New York City, Henry E. Wood & Co., Denver, Colo.

The Imperial Institute,[2] London, has issued a memorandum dealing with the essential facts about the production and uses of molybdenum. The only molybdenum ore of importance is molybdenite, MoS_2. It is widely though usually sparingly distributed, in many countries of the world. The greatest quantities of molybdenite are mined in New South Wales and Queensland, Australia, and in Norway. During 1913 more than half of the world's production of ore came from Australia.

Queensland output in 1915 was 97 gross tons of molybdenite concentrates, that is 80 per cent. MoS_2 or over; in 1914 the production was 78 tons, and in 1913, 57 tons. The Larkin mine, the property of the Irvinebank Co., maintained a monthly output of 1½ tons of molybdenite.

Most of the molybdenite in New South Wales is obtained from the Whipstick mines in the Pambula division. These mines operated continuously in 1915, as did those in the Glen Innes division. In 1913, New South Wales exported 78 tons of molybdenite concentrates.

A recent discovery of molybdenite in the Mt. Perry district is described by L. C. Ball, Government Geologist.[3] The sulphide occurs in quartz and the metal-bearing material is very free from other minerals, even pyrite. A hand-cleaned sample gave 57.7 per cent. molybdenum, 38.7 per cent. sulphur.

At Mount Tennyson, New South Wales, near Yetholme, which is a new molybdenite field, the mine is considered of great promise, and a number of claims have been opened up. Nothing approaching deep sinking has been attempted but the lodes are so large that with a treatment plant on the field a large quantity of ore will soon be placed on the market. A company with a capital of £20,000 is being formed to work some of the leases, and it will not be long before some of the necessary

[1] *Min. & Oil Bull.*, Dec., 1915.
[2] *Imp. Inst.*; *Min. Mag.*, **12**, 280, 1915; *Can. Min. Jour.*, Apr. 15, 1915.
[3] *Queens. Gov't Min. Jour.*, Oct. 15, 1915.

machinery will be installed. About 2 miles south of Mount Tennyson another big lode of molybdenite ore has been located, and a Bathurst party who have secured a 40-acre block intend to open it up.

Agreement was reached between Great Britain and Australia for 12 months delivery of all molybdenite produced at 105 s. per ton per unit of MoS_2, c.i.f. London. The grade is to be not less than 90 per cent. MoS_2 and not over 0.5 per cent. tin and 0.5 bismuth.

There are deposits of molybdenite in several parts of Canada, but there has been practically no production in the past. The demand created at the outbreak of the war aroused renewed activity and 13 gross tons of molybdenite were produced in 1915.

The Government has instituted an investigation of the uses of molybdenum, with the view of analyzing the present outlet for the ores, and of developing other uses for the metal. Good ore occurs in British Columbia, Nova Scotia, and New Brunswick, but the principal bodies are found in Ontario and Quebec. Ore has been found in 60 localities, of which there are 20 in British Columbia, 18 in Ontario and 15 in Quebec.

British Columbia molybdenite occurrences, particularly the "Molly" mine at Lost Creek, are described by C. W. Drysdale.[1] This deposit was discovered in 1913, and is being developed. Fifty tons of ore has been sent to Denver, Col. for concentration; this was picked ore averaging 12 to 16 per cent. MoS_2. The molybdenite lies along the joint planes of granite, associated with pyrite and pyrrhotite. The geological features are discussed.

A concentrating plant is expected to be in operation early in 1916 at the molybdenite mine at Dacre, Ont. The mine has been worked for some time, and the ore is of high grade.[2]

The Orillia Molybdenum Co., Orillia, Ont., has made a shipment of 2 tons of molybdenum concentrates to England, and expects to continue shipments weekly.[3]

Molybdenite is found widely distributed through the granite-gneiss area on the east fork of the Skagway River, Alaska. Some claims have been located preliminary to working.[4]

Newspaper reports of recent date state that at the mining community of Companany, in the Province of Tacna, Chile, there exist considerable deposits of molybdenum and wolfram, in addition to copper sulphides. While the mines have not been developed, samples of the ores have been sent to Europe for the purpose of finding a market for the minerals.[5]

[1] *Bull. Can. Min. Inst.*, Nov., 1915.
[2] *Met. Chem. Eng.*, Nov. 1, 1915.
[3] *Min. Eng. World*, Mar. 11, 1916.
[4] *Min. Amer.*, Nov. 27, 1915.
[5] *Comm. Rept.*, Dec. 4, 1915.

Various molybdenite propositions have been submitted locally since the war created a special demand for this ore, but it does not appear that any of them have proved satisfactory. With molybdenite, as with other rare ores, the difficulty of ensuring a sufficient supply is the chief obstacle to doing business. There are numerous occurrences in the Transvaal tin area which have been known for some years past, but in none of them, as far as we are aware, does the ore occur under sufficiently promising conditions. It is said that some deposits in the old granite in the Low Country are being quietly investigated by a Rand house, but the information available is extremely scanty.[1]

The Deutsche Molybdänwerke at Teuschenthal near Halle on the Saale has been greatly enlarged and improved so that it will be able to supply the whole European steel industry with molybdenum metal and ferro-molybdenum when peace is restored, according to *Zeitschrift für angewandte Chemie.* The company owns mines producing an abundance of the raw material.

The Canadian Department of Mines has installed a Wood flotation plant for experimental work on the concentration of molybdenite. Some tests upon a 2½ per cent. ore containing other sulphides and mica in association with the molybdenite, have led to the adoption of a method of concentration. The ore is crushed and dried, and the larger pieces are hand-picked. Everything not selected in hand picking is broken and sized to less than ⅛ in. The various small sizes are subjected to water-flotation, and the dust to oil-flotation. The concentrates, with 20 to 30 per cent. molybdenite, are roasted at about 1000° F., with care to avoid oxidation of the molybdenite. The roasted concentrates, containing also the oxidized iron sulphides, mica and gangue, are again subjected to water-flotation.[2]

Australian methods of concentration are more or less crude, and consist in the main of dry crushing and screening. Some experiments have been carried out in water- and oil-flotation. For small deposits the ore is hand-crushed, the larger flakes then being hand-picked, while the smaller flakes are saved by hand-sieving. Larger works employ power-driven crushers and rolls, and separate by power shaking screens. Tailings are being saved pending future improvements in methods of concentration.[3]

One plant in New South Wales crushes wet, dewaters the pulp, and mixes it with oil. The oiled mixture is dropped into boxes filled with water; the molybdenite floats, while the gangue material sinks.

The relatively small tonnage of molybdenum needed is a handicap in the exploitation of ore deposits. Any considerable influx of molybdenite

[1] *So. Afr. Min. Jour.*, Oct. 30, 1915.
[2] *Can. Min. Jour.*, Nov. 15, 1916.
[3] *Min. Sci. Press*, Jan. 8, 1916.

is likely to upset the market, and cause prices to fall to an unprofitable level. The chief outlet is in the form of ferro-molybdenum, used as an alloying agent in the manufacture of special steels. Molybdenum steel is used in rifles and guns, and it has been claimed that it has been extensively employed in German armor plate. The statement is generally made that molybdenum is principally used in the manufacture of high-speed steels, and that the metal is a substitute for tungsten, and is required in only about half the quantity. On the other hand, one of the large tool steel manufacturers of this country says that molybdenum does not give as satisfactory a red-hardness as tungsten, and that their only need for molybdenum is in small quantity in the manufacture of self-hardening tool steels.

MONAZITE

By Joseph Hyde Pratt

Previous to 1907 there was considerable activity in the monazite fields of North and South Carolina, but in that year there was a large falling off in the production of monazite, which continued to decrease rapidly until 1911, when the production of monazite in this field ceased altogether. There continued to be a production of monazite in the United States up to the year 1912, this being obtained after 1907 principally from Idaho and other western States. This decrease, which finally ended in no production of monazite in the United States, was undoubtedly due to the low price of imported thorium nitrate. In the early part of 1906, this was selling for practically $6 per lb., but in the latter part of the year it had dropped to $3.75 per lb. Then the price gradually rose in 1907 through 1908, until it reached $4.70 per lb. Then there was a decrease in 1909 to $3.87, and a gradual decrease in price until in the latter part of 1913 it had reached $2.60 per lb. Soon after the outbreak of the European war the price of thorium nitrate began to increase, and in the early part of 1915 the price ranged from $4 to $4.50 per lb. By the latter part of 1915 it had advanced from $5.25 to $6 per lb. For the past few months (March to May, 1916) the price has varied from $6.35 to $7.25 per lb. This rapid advance in price is due largely to the shortage of supply, which at the present time is much below the demand. It is also due partly to the large increase in the cost of raw materials, especially acids used in the manufacture of thorium nitrate. For some time there has been no importation of thorium nitrate into the United States.

It was thought that the continuation of the European war which had curtailed the importation of thorium nitrate from Germany would cause an increased interest in the deposits of monazite in this country and lead to a more general manufacture of thorium nitrate in the United States; but thus far with the exception of a few inquiries regarding sources of monazite and the small amount of monazite sand that has been mined and shipped as samples, there is practically no change in the industry in this country. Even after the war is over, it may be some time before thorium nitrate will be imported, and the production of monazite sands in this country for the manufacture of thorium nitrate, or the importation of such sands from Brazil will undoubtedly take place.

Where formerly the United States was the chief producer of monazite in the world, and there was little or no monazite imported into this country, there is now considerable of this mineral imported into the United States, principally from Brazil. Germany was formerly the larger importer of Brazilian monazite, and also of monazite from this country, but now the greater portion of the Brazilian mineral is shipped to France and the United States.

Monazite Localities

A brief description is given of the Brazilian and the United States monazite localities.

Brazil.[1]—The deposits of monazite sands found in Brazil can be divided into three general groups; those which occur within the Government lands; those lying behind the Government lands, and owned by the State or belonging to private parties; and the inland deposits, which are in occurrence very similar to the Carolina deposits. The Government lands extend for a distance of approximately 300 miles through the States of Bahia, Rio de Janeiro and Espirito Santo. These Government coast lands, called "Marinhas," extend inland for a distance of 33 m. measured from the point where the sea waters wash the beach at mean high tide. It has been almost impossible to definitely determine the boundaries of the Government lands and this has been the cause of many disputes as to rights of lessees. Close behind these Government lands are strips of monazite-bearing sands which belong to the States, or have been disposed of by the States to private parties. These deposits, however, have furnished but a small part of the Brazilian monazite production on account of the difficulties that have arisen of proving to the Federal Government that the monazite sands obtained from these State lands were not taken from the Government lands. One company has been exporting several hundred tons of monazite annually for some years from near Itabapoana in the State of Rio de Janeiro. Several other deposits situated between Gargahu and Itabapoana have been reported as containing workable deposits, if concessions could be obtained for working them. The Government lands have produced the greater part of the monazite exported from Brazil.

The inland deposits occur in the gravels along the small streams and bottom lands, and carry approximately the same percentage of monazite (0.25 to 0.3 per cent.) as the monazite sands in the Carolinas.

Along the banks of larger rivers, as for instance the Parahyba, great quantities of black sands, with traces of monazite are found. Near Sapucaia opposite Benjamin Constant Station on the Central Railway such deposits have been worked by a French concern; but for a short

[1] Karl L. Kithil, *Technical Paper* 110, p. 13; and Bureau of Mines, 1915. *Min. Res. of U. S.*, 1906, pp. 1205–1206, U. S. Geol. Surv.

time they had to stop work at this point and abandon also their openings in the mountainous part of this region. Now, however, mining and concentration of the monazite sands on these rivers has been resumed. The difficulties of mining and transporting the monazite from these inland deposits prevent at the present time their being producers of this mineral, at the low price of monazite.

The exploitation of the Brazilian beach deposits was first undertaken by John Gordon, an American. In the early days of mining Gordon shipped monazite sand as ballast at a cost of less than $15 per ton to Hamburg, Germany, where he realized large profits on it, since the lowest price at that time for sand carrying 5 per cent. of thoria was $95 to $120 per ton. Later he was forced to enter an agreement with a German combination of thorium manufacturers without being able to establish the intended monopoly of the export of Brazilian monazite. In 1903 the Brazilian legislative assembly decided that the deposits of monazite sand along the coast belonged to the Federal Government and forbade their exploitation. Later bids were let for the privilege of working these sands, and the rights were finally secured by A. C. de Freytas Co., of Hamburg. This company guaranteed a royalty of 50 per cent. of the sales made and an annual production of 1700 tons. The de Freytas Co. soon went into partnership with Gordon, and together they made an agreement to sell their whole product to the German thorium syndicate. From the latter they were to receive, in addition to the selling price, a share of the profits from the sale of thorium nitrate. In this way the thorium syndicate has held a partial monopoly over the production of monazite from Brazil.

When it was found that other manufacturers of thorium products were able to obtain supplies elsewhere and that the whole output of Brazil could not be controlled, the German thorium syndicate decided to kill out all competition. Accordingly, in January, 1906, the price of thorium nitrate was reduced to nearly half of that prevailing at the time. The quantity of nitrate sold to each consumer was limited to his demands and was so placed as to conflict with the attempted sales of companies not in the thorium syndicate. In this way the acquisition by brokers of large quantities of low-priced thorium nitrate for speculative purposes was avoided. This cut in price of the nitrate has been injurious or fatal to several smaller manufacturers of thorium products who had supplies of high-priced material in stock, though it has not seriously affected larger, well-established firms mining their own monazite.

Carolina Deposits.[1]—Monazite was first found in the Carolinas in the year 1879 at Brindletown, N. C., by Mr. W. E. Hidden. At the time that

[1] *Bull.* 25, pp. 50–52, N. C. Geol. and Economic Surv.

the monazite placer deposits began to be developed about 1886, localities of commercial value were known to exist in Burke, Cleveland, McDowell, Polk and Rutherford Counties, North Carolina, and in Spartanburg and Greenville Counties, South Carolina. Since that time the area has been very much extended, and now localities containing deposits of monazite sands are known to occur in Alexander, Burke, Catawba, Caldwell, Cleveland, Gaston, Iredell, Lincoln, McDowell, Polk and Rutherford Counties, North Carolina; and in Anderson, Cherokee, Greenville, Laurens, Oconee, Pickens and Spartanburg Counties, South Carolina. The larger towns within or near the monazite region of North Carolina are: Statesville, Taylorsville, Hickory, Rutherfordton, and Shelby; and in South Carolina, Gaffney, Spartanburg, and Greenville.

The deposits are rather favorably located for railroad transportation, as the region is traversed by the Southern, Seaboard Air Line, Carolina and Northwestern, and the Carolina, Clinchfield and Ohio railroads.

Idaho.[1]—Monazite was first reported from Idaho in 1896 by Waldemar Lindgren. No particular attention was paid to the occurrence until 1905, when investigations were carried on by the United States Geological Survey at Portland, Oregon. These investigations were the testing of black sands and their concentrates from various portions of western United States to determine the metals and rare minerals they contained. Sands from many localities in Idaho have been tested and monazite was found in sand deposits on streams in the following counties: Ada, Boisé, Canyon City, Idaho, Lemhi, Lincoln, Nez Perce, Owyhee, Shoshone and Meadows.

Most of the streams in these counties from which the monazite was obtained head near or traverse a very large granite batholith that extends in length a distance of 300 miles north and south through central Idaho, and has been followed eastward through the Bitterroot Range into Montana, varying in width from 50 to 100 miles. This large granite area embraces the whole upper drainage of Boisé and Payette Rivers, extending northeastward beyond the Sawtooth Mountains. The granite areas in the vicinity of Centerville and on Musselshell Creek are supposed to be part of this same great granitic batholith. Monazite has been found in some streams that are apparently without the area of this main granitic area, and it may be that this monazite is derived from granite that is occurring as offshoots or apophyses from the main granitic batholith, which have been intruded into the outlying schists.

India.—Monazite is also produced in India, but it is understood that a recent order of the British Government prohibits the export of monazite sand from India except to the United Kingdom.

[1] Min. Res. of U. S' 1905, pp. 1175–1258, U. S. Geol. Surv.

The United States must look to deposits of monazite within its own borders or to those of Brazil for the raw material with which to manufacture its supply of thorium nitrate. It is also almost certain that the thorium nitrate needed in this country must be manufactured here.

One result of the combination of interests in monazite production which practically controlled the production of this mineral was a demand for the ashes of spent mantles. For several years previous to the beginning of the European war this material had been exported by the German producers and manufacturers instead of shipping monazite. Considerable of this material has been imported into the United States, the import duty on these mantle ashes being $10 ad valorem.

To what extent the spent mantles are being saved in this country is not known. This country has consumed in the past few years at least 80,000,000 incandescent gas mantles. In each of these there is about 0.5 gm. of thoria, ThO_2, which is equivalent to 1 gm. of thorium nitrate. If 30,000,000 mantles are used per year this would make the total consumption of thorium nitrate for this purpose equal to 30,000,000 gm. or 66,135 lb., worth at the present time $7 per lb. or $462,945. As a conservation measure this material should be saved and people should be informed where it can be disposed of.

Supply of Monazite

It has been estimated that the world's consumption of monazite is about 3000 tons per annum, and that the annual world consumption of incandescent gas mantles is estimated at 300,000,000.[1]

Mr. Kithil has made an estimate of monazite resources as follows: "From close calculations, however, it is estimated that the lands in the marinhas along the sea coast of Brazil may yield from 15,000 to 20,000 tons of pure monazite. This does not include coast lands where the deposits have been formed in comparatively short time.

"In the interior of Brazil the writer knows of about 18,000,000 tons of monazite-bearing gravel deposits which should yield monazite containing 4½ per cent. of thorium oxide; and it can be estimated that these gravels contain 45,000 to 60,000 tons of monazite. No doubt there will be found many other deposits of greater or less extent in the interior of Brazil, but no single deposit in the interior, so far as known, would warrant the erection of a large plant. In sections where several large deposits are found together or near each other a washing and concentrating plant might be profitably established, provided that the price for the monazite obtained were higher than at present (May, 1915), and especially if transportation facilities from the interior to the coast became better.

[1] Karl L. Kithil, *Technical Paper* 110, U. S. Bureau of Mines, 1915, p. 9.

"The amount of purified monazite available in the Carolinas may be conservatively estimated at about 15,000 to 20,000 tons (4½ per cent. ThO_2)."

As is seen from the above, the present world's supply of monazite is not very extensive. Taking the maximum figures of supply and the present consumption of 3000 tons per year, there is only enough available monazite to supply the present demand for the next 33 years. New sources of supply are needed; and any new occurrence of monazite is worthy of investigation to determine its commercial possibilities.

Uses of Monazite

As has been intimated, the chief use of monazite is as a source of thorium nitrate, which is used in the manufacture of incandescent gas mantles. These contain 99 per cent. of thoria, ThO_2, and 1 per cent. of ceria, CeO_2.

It has been known for some time that monazite is radioactive, and that it contains a small amount of uranium, and therefore radium. Monazite has also been shown to contain mesothorium, which has properties somewhat similar to radium, and several manufacturers have separated this mesothorium as a by-product in the manufacture of thorium nitrate.[1] There is an increasing demand for this product and while it would not be profitable to treat monazite simply for its mesothorium-content, it is profitable to separate it as a by-product. It is sold on the basis of its activity compared with radium bromide of highest purity (determined by the gamma ray method) and has been sold at $45 to $60 per mg.[2]

There is given in the following table data showing the fluctuation of price of thorium nitrate, which is used in incandescent gas mantles:[3]

This increased price for thorium nitrate should cause the price of monazite to increase and therefore make it possible to produce monazite in the Carolina fields and the inland fields of Brazil, which had to cease their production with the decreased price of monazite.

The Brazilian laws and regulations in regard to mining monazite have retarded in many ways the production of this mineral in Brazil; but since the outbreak of the European war the laws have been changed, and according to Alfred L. M. Gottschalk at Rio de Janeiro,[4] the privileges of small placer miners have been very much increased, and this undoubtedly will have some effect on the developing of the monazite deposits scattered along river beds in the interior.

[1] Haitinger and Ulrich, Bericht über die Bearbeitung der Pechblende Rückstande: *Ber. K. Akad. Wiss.*, **117**, 619, 1908; and Karl L. Kithil, *Technical Paper* 110, p. 25, U. S. Bureau of Mines, 1915

[2] Karl L. Kithil, *Technical Paper* 110, p. 27, U. S. Bureau of Mines, 1915.

[3] Information obtained from Dr. Hugo Lieber, 25 Madison Avenue, New York, N. Y., and Karl Kithel, *Technical Paper* 110, p. 28, U. S. Bureau of Mines, 1915.

[4] *Comm. Rept.*, Mar. 16, 1915, p. 1060.

Year.	Price of Thorium Nitrate.	
	Europe (per Kilo).	United States (per Pound). (*a*)
	Marks.	Dollars.
1894	2000	....
1895, January	900	....
1895, July	500	....
1895, November	300	....
1896, early part	150	....
1896, latter part	96	....
1897	60	....
1898	40	....
1899	30	....
1900	28	....
1902	36	....
1903	43	5.86
1904, early part	43	5.86
1904, latter part	43	6.10
1905	43	6.53
1906	27	3.78
1907, early part	32	3.93
1907, latter part	32	4.65
1908	32	4.70
1909	27	3.87
1910, early part	19	3.20
1910, latter part	17	3.00
1911	22	3.00
1912	22	3.00
1913, early part	21	2.85
1913, latter part	21	2.60
1914, early part	22	2.71
1914, latter part	22	3.25
1915, early part	....	4.00–4.50
1915, latter part	....	5.25–6.00
1916, early part	....	6.35–7.25

(*a*) Data furnished by Dr. Hugo Lieber, 25 Madison Avenue, New York, N. Y.

Production

In the following table there is shown the trend of the monazite industry in the United States for the past few years:

MONAZITE PRODUCTION IN THE UNITED STATES

Year.	United States. (*a*)			North Carolina. (*b*)		
	Pounds.	Value.	Per Pound.	Pounds.	Value.	Per Pound.
1905	1,352,418	$163,908	$0.121	894,368	$107,324	$0.120
1906	846,175	152,312	0.180	697,275	125,510	0.180
1907	547,948	65,754	0.120	(*c*)456,863	54,824	0.120
1908	422,646	50,718	0.120	(*c*)310,196	37,224	0.120
1909	541,931	65,032	0.120	(*c*)391,068	46,928	0.120
1910	99,301	12,006	0.121	83,454	10,104	0.121
1911	3,561	427	0.120	400	48	0.120
1912	1,272	159	0.120	*Nil.*	....	....
1913	*Nil.*	....	....	*Nil.*	....	....
1914	*Nil.*	....	....	*Nil.*	....	....
1915	(*d*)	....	....	(*d*)	....	....

(*a*) Statistics are those of the U. S. Geological Survey. (*b*) Statistics for N. C. from 1893 to 1902 are estimates; those from 1903 to 1906 are from "The Mineral Industry of North Carolina;" those for 1910 are furnished by Joseph Hyde Pratt, State Geologist. (*c*) Statistics for 1907, 1908, and 1909 were collected jointly by the U. S. Geological Survey and the N. C. Geological and Economic Survey. (*d*) As there was only one producer in 1915, statistics can not be given.

Imports

The imports of thorium nitrate and of monazite sand for the past 6 years are given in the table below:

IMPORTS OF THORIUM NITRATE AND MONAZITE (a)

	Year.	Pounds.	Value.	Per Pound.
Thorium nitrate entered for consumption..........	1910	108,597	$218,713	$2.01
	1911	121,111	238,841	1.97
	1912	117,485	225,386	1.92
	1913	112,105	212,263	1.89
	1914	101,927	239,376	2.35
	1915	67,406	169,617	2.52
Monazite sand (and thorite) entered for consumption.	1910	453,554	$39,699	$0.0875
	1911	705,149	60,542	0.086
	1912	556,959	47,334	0.085
	1913	1,145,010	94,425	0.082
	1914	770,842	61,595	0.080
	1915	1,873,971	161,456	0.117

(a) Bureau of Statistics of the Department of Commerce and Labor.

NICKEL AND COBALT

By James Aston

United States.—The United States has continued to occupy its usual position in the nickel industry; while the all-important producer of the metal, this output has been from raw materials obtained from beyond the borders. Production in 1915 exceeded that of any previous year. The unusual demand for nickel for armanent and munitions purposes gave a decided stimulus to production.

Imports for 1915 are given as 56,352,582 lb., chiefly in the form of ore and matte, as compared with 35,006,770 lb. in 1914 and 47,194,101 lb. in 1913. Exports, largely as the metal, were 26,418,550, 27,595,152, and 29,173,088 lb. in the respective periods.

Complete statistics for several years past are noted below, together with destination of exports:

Year.	Imports.							Exports.	
	Nickel Ore and Matte.		Nickel Alloys. (*a*)		Nickel Mnfrs.	Cobalt Oxide.		Nickel. (*b*)	
	Long Tons.	Value.	Pounds.	Value.	Value.	Pounds.	Value.	Pounds.	Value.
1901.	52,111	$1,637,166	635,697	$209,956	$ 2,498	71,969	$134,208	5,869,655	$1,521,271
1902.	14,817	1,156,372	752,630	251,149	30,128	79,984	151,115	3,228,607	925,579
1903.	15,936	1,285,935	521,344	170,670	37,284	73,350	145,264	2,414,499	703,550
1904.	8,548	915,470	589,555	203,071	2,950	42,352	86,925	7,519,206	2,130,933
1905.	13,451	1,626,920	941,966	331,920	3,291	70,048	139,377	9,550,918	2,894,700
1906.	15,156	1,816,631	210,000	77,373	8,963	41,084	83,167	10,620,410	3,493,643
1907.	(*d*)16,888	2,153,873	180,025	80,994	9,159	48,013	74,849	8,772,578	2,845,663
1908.	(*e*)16,322	2,396,217	241,868	91,388	10,010	219,098	17,077	9,770,248	3,297,988
1909.	(*f*)18,578	2,927,975	277,911	104,019	4,279	12,132	11,096	12,048,737	4,101,976
1910.	(*g*)28,519	4,085,076	323,239	125,013	14,759	6,124	4,806	15,244,937	4,704,088
1911.	(*h*)23,993	3,918,556	293,301	104,160	.....	14,561	7,576	25,099,586	8,283,777
1912.	(*i*)33,101	5,638,456	(*j*)223,168	103,300	17,203	31,848	15,132	25,815,016	8,515,332
1913.	(*k*)37,623	6,427,639	336,590	133,917	37,200	47,277	26,154	29,173,088	9,686,794
1914.	29,564	4,956,448	109,213	45,146	13,010	227,886	220,593	27,595,152	9,455,528
1915.	45,798	7,615,999	32,487	13,687	6,242	154,672	148,828	26,418,550	10,038,514

(*a*) Includes nickel oxide, and alloys of any kind in which nickel is the material of chief value, in ingots, bars, and sheets. (*b*) Comprises domestic nickel, nickel oxide, and matte. (*d*) Contained 18,418,305 lb. nickel; not reported previous to 1907. (*e*) Contained 16,586,423 lb. nickel. (*f*) Contained 21,916,182 lb. nickel. (*g*) Contained 32,050,032 lb. nickel. (*h*) Contained 29,545,967 lb. nickel. (*i*) Contained 42,168,769 lb. nickel. (*j*) Weight of nickel alloys only, value $85,059. (*k*) Contained 47,194,101 lb. nickel.

Exports of Nickel from United States, Pounds.	1912.	1913.	1914.	1915.
To France	5,083,947	3,631,858	3,457,157	3,018,354
To Netherlands	7,387,447	6,622,811	855,168	129,557
To United Kingdom	8,191,364	8,221,640	10,836,369	14,801,565
To other countries	5,152,258	10,096,779	12,446,458	8,469,074
Total	25,815,016	29,173,088	27,595,152	26,418,550

Over half of the exports went to the United Kingdom. The small shipments to the Netherlands in 1914 and 1915, especially the latter, indicate that Germany has not been receiving material from this country, at any rate through the usual port of entry.

The International Nickel Co. has produced almost all of the domestic output at its Constable Hook, N. J., plant, from matte received from the Canadian Copper Co., a subsidiary corporation operating mines and smelters in the Sudbury district, Ontario.

The 14th report of the International Nickel Co.[1] for the fiscal year ended Mar. 31, 1916, shows earnings of all properties after deducting manufacturing and selling expenses and ordinary repairs and maintenance, as $14,340,966. Net profits for the year after deduction of all administration expenses, taxes, depreciation and mineral exhaustion, were $11,748,278. The year previous, net profits were $5,598,071. Dividends of $534,756 were paid on the preferred, and $9,431,803 on the common stock; $1,414,807 was expended for property, construction and equipment. For the past fiscal year there were 7145 stockholders against 4465 a year before. In reply to the statements in Canada that the company is dominated by German capital, it is asserted by officials that control is entirely in the hands of American capitalists, and that less than 500 shares of this stock are owned in Germany and Austria, out of a total of 469,441 shares.

The International Nickel Co. has ore deposits at Sudbury, Ont., in a tract 36 miles long and 16 miles wide, with estimated reserves of 57,000,000 tons of paying ore. Also 9217 hectares by complete ownership, and 3848 hectares in joint ownership in New Caledonia. The entire production is obtained from Canada, since the New Caledonian properties are not being operated except in a very small way.

The Canadian Copper Co., a subsidiary, operates seven large blast furnaces, five basic converters, and a large reverberatory plant at Copper Cliff, Ont., with a capactiy for treating 100,000 tons of ore monthly. A nickel-copper matte is produced which is shipped to the refineries at Constable Hook, N. J. Five large nickel furnaces, thirty-one calcining furnaces, five refining furnaces, two copper blast furnaces and five copper reverberatories with necessary converting equipment, produce nickel and copper for the market by the Orford process.

The price of nickel remained fairly steady throughout the year. Quotations at New York were 40 to 50 cts. per lb. for shot, blocks or plaquettes, according to quantity and terms of order, for the first 7 months of the year. There was a rise of 5 cts. in the last 5 months.

[1] *Eng. Min. Jour.*, June 10, 1916.

Electrolytic nickel was sold at an advance of 5 cts. per lb. over ordinary grades.

Canada.—The output of nickel in Canada in 1915 was 37 per cent. greater than in any other year.[1] The total production of matte was 67,703 short tons containing 39,216,165 lb. of copper and 68,077,823 lb. of nickel. The tonnage of ores smelted (part being previously roasted) was 1,272,283. The 1915 output of matte was 46 per cent. greater than the 46,396 tons produced in 1914. In 1914 the matte contained 28,895,825 lb. of copper and 45,517,937 lb. of nickel. Comparative figures of production and export are noted in the following table:

CANADIAN PRODUCTION AND EXPORT
(From Preliminary Report, Mineral Production of Canada—1915)

	1912.	1913	1914.	1915.
Ore mined (short tons)	737,584	784,697	1,000,364	1,364,048
Ore smelted (short tons)	725,065	823,403	947,053	1,272,283
Bessemer matte produced (short tons)	41,925	47,150	46,396	67,703
Copper content of matte (short tons)	11,116	12,938	14,448	19,608
Nickel content of matte (short tons)	22,421	24,838	22,759	34,039
Spot value of matte	$6,303,102	$7,076,945	$7,189,031	$10,352,344

	Lb., 1912.	Lb., 1913.	Lb., 1914.	Lb., 1915.
Nickel contained in matte, etc.:				
Exported to Great Britain	5,072,867	5,164,512	10,291,979	13,748,000
Exported to United States	39,148,993	44,224,119	36,015,642	52,662,400
Exported to other countries	....	70,386	220,706	....
	44,221,860	49,459,017	46,538,327	66,410,400

Exports of nickel ore are reported by the Customs Department as 66,410,400 lb. valued at $7,394,446, or 11.13 cts. per lb. About 80 per cent. is shipped to the United States.

The output of nickel has been chiefly from the nickel-copper ores of the Sudbury district, supplemented by a small tonnage of similar ores from the Alexo mine in Temiskaming, north of Cobalt. Refined nickel was produced for the first time in Ontario, but in relatively small quantities only, as a by-product in the smelting and refining of the silver-cobalt-nickel ores of the Cobalt district. Nickel oxide has been recovered in these smelters for several years. The reported recovery from the ores of the Cobalt district in 1915 was 55,325 lb. of nickel and 200,032 lb. of nickel oxide. The recovery in 1914 was 392,512 lb. of nickel oxide.

The nickel-copper ores are produced by 12 separate mines; the largest of which is the Creighton, of the Canadian Copper Co., which produces about 75,000 tons a month. This ore carries about 3 to 4 per cent. of nickel and 2 per cent. copper, as sulphides.

[1] Mineral Prod. of Canada, 1915.

Production of matte is confined to the Canadian Copper Co., at Copper Cliff, and the Mond Nickel Co. at Conniston; their proportions of the total being about 75 and 25 per cent., respectively. In 1915 the Canadian Copper Co. smelted 865,169 tons of ore, and the Mond Nickel Co. 407,144 tons. Both plants produce a converter matte carrying from 75 to 80 per cent. of nickel plus copper, the Copper Co.'s matte running about Ni 50, Cu 25, and that of the Mond Co. Cu 40, Ni 40. Both concerns ship the matte to refineries abroad, the product of the Canadian Copper Co. going to New Jersey, and that of the Mond Nickel Co. to Wales. A portion of the matte produced by the former company is smelted without intermediate refining of either metal, for the direct production of Monel metal, an alloy of nickel and copper.

A third concern, the British-American Nickel Corporation, acquired extensive deposits of ore, and intends to enter the field, but the plans were interfered with by the war.

Vickers and Maxim, the noted gun manufacturers of England, are financing an extensive expedition to explore the Fond du Lac region in northern Alberta, in search of nickel deposits, which are believed to occur extensively in that country. The party is in charge of a prospector who recently returned from the district with rich specimens of nickel ore.[1]

The agitation in Canada regarding the prohibition of export of nickel ores or matte to other countries, and which was aimed primarily at the International Nickel Co. remained a topic of lively interest and argument during the year. The situation was not cleared to any appreciable extent. On July 20 a commission of four experts was appointed to consider the advisability of refining nickel entirely within the province of Ontario. The investigation was soon inaugurated but no reports have been made during the year.

The conservative element in Canada appear to be satisfied with the existing arrangement between the Government and the Nickel Co., whereby the former has entire access to the books of the latter. However, there is a well-founded desire to have some of Canada's nickel refined in the Dominion. As a result of negotiations, the International Nickel Co. just after the close of 1915, agreed to erect a refining plant in Canada, at such point as seemed to be most economical for operation, and of such initial capacity that Great Britain and Canada would be secured to the extent of their requirements.

Early in 1916 the Canadian Government prohibited the export of nickel, save to British possessions. However, a special license was granted to the International Nickel Co., so that it can get all the nickel it needs from its mines in Canada.

[1] *Iron Tr. Rev.*, Oct. 14, 1915.

Nickel and Cobalt in Cuba (By Joseph T. Singewald, Jr., and Benjamin LeRoy Miller).—A fact of unusual interest is the presence of an appreciable nickel-content with some associated cobalt in the lateritic iron ores of the north coast of eastern Cuba in the province of Oriente and the eastern part of the adjoining province of Camagüey. Over 2,000,000,000 tons of such ores have been developed in the three largest districts; and in the Mayari district, in which the ores are being mined, the average nickel-content is about 1 per cent., but there are areas in which the nickel-content goes as high as 2½ per cent. In mining these ores they are separated into high-nickel ores, or those running over 1.2 per cent. and low-nickel ores that average under 1 per cent. nickel.

The nickel-content results from the nickel contained in the original serpentine of which the ores represent the residual products of weathering. Large samples of the serpentine have shown a nickel-content as high as 1.2 per cent., though the average is less. It has also been found that rock averaging only 0.5 per cent. nickel would yield samples taken from long crevices and joints that contained 1.5 nickel, indicating a segregation on a small scale of the nature that gave rise to the hydrated nickel ores.

Since important nickel deposits have been formed elsewhere from nickeliferous serpentines by processes essentially the same as those that gave rise to the iron ores, considerable attention has been directed to the study of the nickel-content of these deposits in the hope of finding some pockets of highly nickeliferous iron ores or even veins of hydrosilicate nickel ores in the underlying serpentine. They have recently been investigated from this standpoint by Prof. Willet G. Miller, provincial geologist of Ontario, who is a member of the Royal Nickel Commission appointed a short time ago by the British government. The curve showing the relative change in the constituents of the serpentine in passing from it to ore and from the bottom of the ore to the surface published in an article by Leith and Mead in the July *Bulletin* of the American Institute of Mining Engineers lends considerable hope to such a search. From this curve it is seen that in the lower layers the ore carries a greater percentage of nickel than did the serpentine due to the rapid removal of magnesia and silica. As the surface is approached, the relative amount of nickel becomes less, until close to the surface it takes three times as much ore by weight to contain as much nickel as does a given weight of serpentine. Further, since the ore represents but a small part of the original serpentine, it is clear that a great deal of nickel has been taken into solution and carried downward by the atmospheric waters. If conditions have been favorable anywhere for the accumulation of this nickel, it is very likely nickel ores have been formed at such places. Although none such have been discovered, there is always the possibility of such a discovery; and at all events, the constantly present low nickel-content of the iron ores adds to their value in the manufacture of steel.

Other Countries.—Shipments of nickel ore from New Caledonia were 48,476 metric tons in 1915. Exports in 1914 were reported as 94,154 tons, and 93,190 tons in 1913. Total output of ore is given as 172,365 tons in 1914, and 164,404 tons in 1913. In 1914, 5287 tons of nickel matte were exported, a decrease of 606 tons from the year previous.

Deposits of nickel are reported in East Griqualand, along the Insizwa Range, in South Africa. The ores are chalcopyrite and pentlandite with pyrrhotite, disseminated through a gigantic sill of gabbro. The sulphides form veins and lenses of considerable richness in places, but the actual ore-body, if worked, would be a gabbro containing sulphides to the amount of 5 or 6 per cent. So far as surface evidence goes, it is a low-grade proposition, but further exploration may reveal better ores. The quantity of copper slightly exceeds that of nickel.[1]

Russian nickel deposits in the Urals, which have not heretofore been worked on account of the low grade of the ore, are now being exploited. The Redwinsk smelting works are reported to be turning out nickel matte at the rate of 600 tons yearly.[2]

Technology.—U. S. patents 1,123,299 and 1,128,315 have been issued to N. V. Hybinette on a process for the electrolytic separation of nickel and copper. Inconvenient cathode reactions resulting from the presence of iron salts may be avoided by putting the cathode in a porous compartment which serves as a filter; for instance a lead screen with asbestos filling.[3]

Monel metal, the natural alloy of about 68 Ni, 30 Cu, 1.5 Fe, obtained by direct reduction of Sudbury nickel-copper ores, is finding a broad field of usefulness where high strength and non-corrosive qualities are desired. Large valves and valve stems and seats are now being made of the metal to withstand high steam pressures and superheats, also sea-water pumps, chemical equipment, and pickling apparatus for sheet and tin plate.

A. A. Read and R. H. Greaves[4] have studied the nickel-aluminium and copper-nickel-aluminium alloys. Nickel acts with aluminium somewhat like copper, increasing the strength and elasticity and lowering the ductility for alloys with nickel up to 5.5 per cent., the limits of the tests. Hardness, and rate of corrosion are increased, while electrical conductivity and resistance to alternating stress are decreased. Replacement of more than 2 per cent. of the nickel by copper is of no advantage. Corrosion is more marked as the percentage of copper plus nickel increases.

S. W. Parr[1] has developed an acid resisting alloy, essentially a nickel-

[1] *Aust. Min. Jour.*, Mar. 11, 1916.
[2] *Eng. Min. Jour.*, Nov. 6, 1915.
[3] *Eng. Min. Jour.*, Oct. 23, 1915.
[4] *Inst. of Metals*, Mar. 19, 1916.

chrome alloy with moderate percentages of several other metals. Nickel is about 60 and chromium 21 per cent. It was primarily developed for use in calorimeter bombs. Casting and drawing qualities are not good; it freezes very quickly and has excessive shrinkage. The tensile strength is about 50,000 lb. per sq. in. with low ductility. The alloy is practically non-corrodible in 25 per cent. nitric acid.

Addition of 5 to 10 per cent. of tantalum to nickel considerably increases the metal's acid resistance. An alloy with 30 per cent. tantalum is not attacked by aqua regia. The alloy is tough and ductile.[2]

Aluminium is being successfully electroplated with nickel, the process having been patented in France. Good adherence is claimed by direct deposition, without any intermediate metal. Details of preparation, bath, and operation are discussed.[3]

Experiments on the electrodeposition of nickel are reported by C. W. Bennett, C. C. Rose, and L. G. Tinkler.[4] Conditions for efficient plating are discussed.

P. Chevenard[5] points out that the peculiar properties of nickel steels containing high percentages of nickel make them a class apart from all other steels. Alloys of less than 34.45 per cent. of nickel consist of a solid solution of iron and Fe_2Ni. Dilatation and magnetic reversibility are considered. From the researches carried out on the specific volumes of the ferro-nickels the conclusions are drawn that the amplitude of the reversible anomaly is directly proportional to the amount of Fe_2Ni present in the alloy, while that of the irreversible transformation is proportional to the amount of free iron present in the solid solution.

C. W. Heaps[6] describes experiments on the contraction and resistance of iron and nickel in a magnetic field, and their initial relations.

Cobalt

There is considerable cobalt metal used by manufacturers of high-speed tool steel and stellite, and it has been generally acknowledged that the addition of a small percentage of the metal will produce a tool of greatly enhanced cutting qualities. It is growing in popularity although, as in the case of ferro-vanadium, its fluctuations have been somewhat lost sight of in the rush for other more necessary alloying metals. Advances in price have not been very serious, and since Canada is the principal source of raw material supplies have not been seriously curtailed. The available deposits of cobalt ores are large and there should always be

[1] *Iron Tr. Rev.*, Nov. 18, 1915.
[2] *Eng. Min. Jour.*, May 8, 1915.
[3] *Eng. Mag.*, May, 1915.
[4] *Trans. Amer. Electrochem. Soc.*, **28**, 339 (1915).
[5] *Rev. de Metal.*, **11**, 84 (1914).
[6] *Elec.* (Lond)., Oct. 1, 1915.

a sufficient quantity of the oxide obtainable, although reasonable fluctuations may be expected from time to time.[1]

The principal supplies of cobalt have been obtained from Canada, where the oxide was recovered as a by-product in the treatment of the silver ores of the Cobalt district in Ontario. Production in 1915 is reported by the Department of Mines to be 211,610 lb. of the metal, and 379,219 lb. of oxide, with a combined value of $502,388.

For previous years the output of cobalt oxide was 899,027 lb. in 1914, 660,079 in 1913, and 257,677 lb. in 1912.

Metallic cobalt was quoted at $1.60 to $1.70 per lb. in August, 1915.

The chemical and mechanical relations of iron, cobalt and carbon have been investigated by J. O. Arnold and A. A. Reed.[2] Increasing amounts of cobalt added to steel increases the strength and elasticity, but lowers the ductility, as compared with plain steels of the same carbon-content. Cobalt tends to throw out the carbon from the combined form to the graphitic, for steels of 0.64 per cent. carbon and over, and with cobalt in excess of 2.68 per cent. The amount of graphitic carbon increases with the cobalt-content, and large quantities precipitate all of the carbon as graphite. The action of cobalt is unlike that of nickel in this respect.

T. D. Yensen[3] describes his researches on the magnetic properties of a pure iron-cobalt alloy. An alloy of the composition Fe_2Co has a saturation value of magnetization higher than that of pure iron; its permability is considerably higher than that for pure or commercial grades of iron, and its hysteresis is equal to that of commercial transformer iron at higher flux densities. The alloy is brittle, but fairly strong.

The third publication dealing with the results of investigations of the Canadian Department of Mines on the cobalt and its uses, is the work of H. T. Kalmus, C. H. Harper, and W. L. Savell.[4] It deals with cobalt electroplating. Baths and details of operation are given. Various metals can be coated with cobalt under conditions observed in nickel plating; the deposits are firm, adherent, hard, and uniform, and take a brilliant polish. Current densities of 90 to 100 amp. per sq. ft. may be successfully used, or vastly higher than in depositing nickel. Good coats may be obtained in a few minutes. Cost of the cobalt is the chief hindrance to wider application at the present time.

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[1] DeC. Browne, *Iron Age*, Jan. 6, 1916.
[2] *Inst. Mech. Engrs.*, Mar. 19, 1915.
[3] *Elec.*, **26**, 52 (1915).
[4] *Bull.* 334, Can. Dept. Mines.

PETROLEUM AND NATURAL GAS

By David T. Day

Introductory.—Without any great change in the total volume of petroleum produced in the United States, the year 1915 was nevertheless epoch-making, on account of greatly increased production in the Cushing Pool of Oklahoma. There the total product rose to 70,000,000 bbl., 60 per cent. of the State's production and as much as Oklahoma's total product in any year prior to 1914. This caused a great drop in the prices for crude oil. In fact, the decline was felt abroad and even effected a reduction in the price of Scotch shale oil.

This increase in Oklahoma was largely offset by declines in some other States, especially in California. But the oil conditions in California have little effect upon the eastern States, hence the decline was powerless to prevent the decline in prices in which all eastern crude shared. Cushing crude is especially rich in gasoline, and the large supply checked the rise which had begun in the price of gasoline in the early part of the year.

Stocks increased in the mid-continent field and were about stationary in California, where the decline in production represented a return to the consumption demand. In other States stocks declined, leaving the supply in about the average condition at the end of the year, with the prospect that gradually increasing refining demands would draw upon stocks during 1916.

PRODUCTION OF PETROLEUM IN THE UNITED STATES BY FIELDS, 1910–1915
(In barrels) (*a*)

Field.	1910.	1911.	1912.	1913.	1914.	1915.
Appalachian	26,892,579	23,749,832	26,338,516	25,921,785	24,101,048	22,860,048
Lima-Indiana	7,253,861	6,231,164	(*b*) 4,925,906	4,773,138	5,062,543	4,269,591
Illinois	33,143,362	31,317,038	28,601,308	23,893,899	21,919,749	19,041,695
Mid-Continent	59,217,582	66,595,477	65,473,345	84,920,225	97,995,400	123,295,867
Gulf	9,680,465	10,999,873	8,545,018	8,542,494	13,117,528	20,577,103
California	73,010,560	81,134,391	(*c*) 87,272,593	97,788,525	99,775,327	86,591,535
Colorado and Wyoming.	(*d*) 358,839	(*d*) 421,616	1,778,358	2,595,321	3,783,148	4,454,000
Other fields	....	....	....	(*e*) 10,843	(*f*) 7,792	(*f*) 24,295
Total	209,557,248	220,449,391	222,935,044	248,446,230	265,762,535	....

(*a*) Statistics of the U. S. Geological Survey. (*b*) Includes Michigan. (*c*) Includes Alaska. (*d*) Includes Michigan and Missouri. (*e*) Includes Alaska, Michigan, Missouri, and New Mexico. (*f*) Includes Alaska, Michigan and Missouri. (*g*) Includes Colorado and Wyoming.

Oil Exports for 1915

The exports of mineral oils for 1915, according to the figures of the Bureau of Foreign and Domestic Commerce, amounted to 2,309,760,792 gal., valued at $141,004,663. In 1914 the corresponding figures were 2,224,250,324 gal. and $138,381,994.

The exports by months for the years 1912, 1913, 1914 and 1915 are given in the following table. The increase of 1915 began with stimulation which began in May. Exports rose to a high point in September and then declined steadily.

	1912.	1913.	1914.	1915.
January	132,160,209	168,170,286	163,830,375	146,273,872
February	110,618,086	129,026,557	151,251,958	151,742,942
March	122,254,481	148,935,705	173,095,529	167,152,694
April	163,206,438	171,498,655	221,052,913	169,585,645
May	195,734,654	174,851,170	196,196,201	225,951,698
June	147,859,275	185,643,586	217,744,327	210,358,304
July	186,196,374	176,685,335	230,269,485	215,595,691
August	166,618,226	182,584,132	145,763,792	232,224,014
September	182,896,451	191,555,641	201,645,938	214,738,871
October	148,863,918	219,474,668	193,973,497	204,607,069
November	181,012,206	171,537,378	167,843,001	186,817,899
December	146,059,579	216,502,608	166,860,557	184,712,183
Year	1,883,479,397	2,136,465,721	2,240,033,652	2,309,760,792
Value, year	$124,210,382	$149,316,409	$139,900,587	$141,004,663

Growth of Petroleum-refining Industry

The value of the annual production of the petroleum-refining industry of the country, according to the preliminary report by the United States Bureau of the Census, increased 67.2 per cent. between 1909 and 1914. The total cost of the crude petroleum increased 64 per cent. between those years.

The production of naphthas and lighter products, chiefly gasoline, increased from 10,806,550 bbl. in 1909 to 29,200,764 bbl. in 1914, while the value increased from $39,771,959 to $121,919,307. The output of fuel oils increased from 34,034,577 bbl., valued at $36,462,883, to 74,-669,821 bbl., valued at $84,017,916. Illuminating oils show an increase in quantity from 33,495,798 bbl., valued at $94,547,010, to 38,705,496 bbl., valued at $96,806,452, or an increase of 11.7 per cent. in quantity and of 2.4 per cent. in value. On the other hand, lubricating oils show a decrease in quantity with an increase in value, from 10,745,885 bbl., valued at $38,884,236, to 10,348,521 bbl., valued at $55,812,120. The decrease in lubricating oils is only apparent and due to re-classification. All other products, including residuum or tar, greases, paraffin wax, asphalt and subsidiary and by-products, increased in value from $27,331,571 to $37,805,610, or by 38.2 per cent.

The gasoline product of the petroleum refineries does not include casing-head gasoline condensed from natural gas at the gas wells. The total gasoline production, including casing-head gasoline, was 24,711,565 bbl. of 50 gal., or 1,235,578,250 gal.

The Development of Medicinal Oils.—In considering the technologic developments of the oil industry of the United States, there are many items which represent promising beginnings, but the development of medicinal oils may be said to be completed—and just at a time when the Russian supply was inadequate and varied greatly in quality. As the result of the year's work two medicinal oils, that produced by the Standard Oil Co. of New Jersey, under a patented name, and that developed by Dr. Mann for the Standard Oil Co. of California, are considerably superior to any imported from Russia. They give first place to the United States in this technical feat. The greatly increased use of such petroleum products for internal medication has been emphasized by a thorough study of this subject by the oil committee of the commission engaged in revising the U. S. Pharmacopeia.

Oil Shales

Stimulated by the work of the U. S. Geological Survey and the Bureau of Mines, by the higher prices for crude oil and in one instance by a demand for ammonia, various projects have been launched for utilizing the oil shales of western Colorado and in various Utah localities. None has reached the productive stage, but it is altogether probable that more than one project will ultimately be successful.

Meantime the Government bureaus mentioned above and private enterprise have added much to the general knowledge of the occurrence of oil shales and it is not easy to select areas where the shales are abundantly rich in oil, and, provided transportation facilities can be made adequate, they should prove profitable.

The literature of the year includes a valuable article on the subject of oil shales in various parts of the world and especially those of the Kimmeridge series in Dorsetshire, England, by W. Hardy Manfield, and published by the Institute of Petroleum Technologists.

It is encouraging for the oil resources of Great Britain that Mr. Manfield finds the sulphur in the Kimmeridge shales as the only obstacle to their utilization; as a matter of probability, this sulphur will easily prove a benefit rather than a detriment in the working of these shales.

It is interesting to note that the richer the shales, in the United States at least, the greater the proportion of oil already existing in the pores of the shale and easily extractable by solvents—as if the shales carried a certain maximum of organic matter convertible into oil by destructive distillation, and these shales have in the better grades been enriched by the infusion of oils which, by the way, are generally higher grade than the destructive distillation products.

The Petroleum Reserves of the United States

At the Pan-American Scientific Congress held in Washington in January, 1916, Mr. Ralph Arnold, petroleum engineer, contributed an unusually noteworthy paper on the oil fields of the western hemisphere, in which he summed up the probable oil reserves of each country. Among the interesting features of the paper was the recognition given to the important position of Mexico's oil fields in comparison even with the United States, and the low total estimated for the oil reserves in the United States. The summary of the paper as published in *Economic Geology* contains a table of the United States oil reserves, which, while it probably will be revised upward rather than downward, should be given a prominent place in oil literature. It follows on the succeeding page.

Petroleum in the United States

California.—Consistent effort to reduce drilling to the needs of the consumers was the all-important feature of the oil situation in California in 1915. The extreme difficulty of carrying out such a policy can hardly be appreciated by any but those actively engaged in California's oil production. Many important oil producers were barely covering costs of production by the amount obtained for their oil. Any considerable increase in price on the part of the purchasers meant artificial stimulation of drilling. Fortunately the counsels of the more broadly conservative producers, McQuigg, Requa, St. Clair, O'Donnell and others, were effective in reducing the output from 99,775,327 bbl. in 1914 to less than 90,000,000 bbl. in 1915. The usual long list of heavy gushers is conspicuously absent. The work of the year gives more comparative importance to the Coyote Hills region in the southern fields, and work in Coalinga added increased stability to that region.

In spite of many discouragements incident to the marketing of heavy oil, the Independent Producers Agency maintained its standing and remains the only successful producers' organization. In the refining and marketing branch of the California industry the advent of the Dutch Shell interests with a refinery at Martinez was of interest. There was a general tendency to increase the magnitude of all refineries and also to enter into the manufacture of new products.

The remarkably complete exhibits at the Panama-Pacific Exposition

PAST AND ESTIMATED FUTURE PRODUCTION OF PETROLEUM IN THE UNITED STATES

State.	Age of Containing Rocks.	Base.	Quality of Oil.	Production for 1914.	Total Prod., Including 1914.	Probable Future Supply.	Proven Area.	Prospective Area.	Average Prod. per Acre.	Per Cent. Exhaustion.
Alaska	East-Low. Tertiary West-Jurassic.	Paraffin	39°–45.9° Bé. 0.8284–0.7958	....	....	10,000,000	.....	15	1,000	0
California	Cretaceous; Tertiary	Asphalt	12°–35° Bé. 0.9859–0.8484	99,775,327	741,273,559	2,300,000,000	156	40	30,000	24
Colorado	Pierre-Cretaceous	Paraffin	38°–44° Bé. 0.8333–0.8045	222,773	10,649,143	21,000,000	17	33	1,000	33½
Illinois	Mississippian-Penna.	Paraffin	28°–39° Bé. 0.8860–0.8284	21,919,749	232,326,616	400,000,000	400	100	2,500	36+
Indiana	East-Ordovician (Trenton) West-Pennsylvanian.	Paraffin	30°–35° Bé. 0.8750–0.8484	1,335,456	102,823,798	20,000,000	500	100	400	83+
Kansas	Pennsylvanian	Par.-Asph.	27°–38° Bé. 0.8917–0.8333	3,103,585	28,547,074	40,000,000	70	30	1,500	42
Kentucky and Tennessee	Mississippian	Paraffin	25°–43° Bé. 0.9032–0.8092	502,441	9,095,970	10,000,000	100	100	300	47
Louisiana	Cretaceous-Quaternary, Cretaceous-Eocene.	Paraffin	21°–41° Bé. 0.9271–0.8187	14,309,435	89,895,433	170,000,000	87	40	4,500	34
Michigan, Missouri	Carboniferous	Paraffin	30° Bé. 0.8750	7,792	72,712	100,000	1	.....	......	58
New Mexico	Carboniferous-Cretaceous	....	....	....	....	....	.....	25	......	.....
New York and Penna.	Devonian-Carboniferous	Paraffin	25°–50° Bé. 0.9032–0.7778	9,109,309	754,180,215	135,000,000	1,400	100	1,000	85
Ohio—East and West	Ordovician-Carboniferous	Paraffin	35°–47° Bé. 0.8484–0.7909	8,536,352	432,762,004	205,000,000	115 535	 50	1,500	67
Oklahoma	Pennsylvanian	Paraffin	32°–41° Bé. 0.8641–0.8187	73,631,724	461,833,466	1,545,000,000	297	73	10,000	22
Texas	Pennsylvanian, Cretaceous-Quaternary.	Asphalt and paraffin.	15°–38° Bé. 0.9655–0.8333	20,068,184	203,799,381	400,000,000	50	150	17,000	33+
Utah	....	....	22°–40° Bé. 0.9210–0.8235	....	....	....	.....	20	......	.....
West Va.	Devonian-Carboniferous	....	27°–52° Bé. 0.8917–0.7692	9,680,033	260,232,815	207,000,000	350	50	2,000	55+
Wyoming	Carboniferous-Cretaceous	Asphalt-Paraffin.	18°–48° Bé. 0.9459–0.7865	3,560,375	7,964,944	300,000,000	31	20	15,000	2
				256,762,535	3,345,457,130	5,763,100,000	4,109	946	......	36

made by the Standard Oil Co. of California and by the Union Oil Co. gave the first really sufficient opportunity for realizing the extent to which California oil products are complete in themselves and independent of the East. Beyond doubt, the most important of these achievements is the pioneer work of the Standard Oil Co. of California in producing high-grade lubricating oils and greases. It is well known that these oils excel in low cold test, but one hardly expected to find all grades of lubricants made entirely from California stock—even high-grade cylinder oils to an increasing extent. Enough attention has been given to gasoline and burning oils so that the quality is exceptionally good, and gasoline is about 6 cts. per gal. cheaper than in the East. In fact, a recent trade development has been the shipment of considerable quantities of "engine distillate" from California to eke out the gasoline supply of the eastern States. More gratifying still to the oil economist is the development of many interesting by-products from California oils, such as solvents, cleaning oils, creosoting oils and especially the great amount of technical research that has been applied to the important question of asphalt pavements and road construction.

But the greatest achievement in by-products by the California Standard Oil Co. has been the production of medicinal oil very similar to the Russian product, but more uniformly of high grade. It will be remembered that both Russian and Californian oils are characterized by the presence of naphthenes in the crude oil. The Californians have succeeded in producing from these naphthenes medicinal oils which do not vary in purity as the various Russian makes do.

THE OUTPUT OF THE VARIOUS FIELDS OF CALIFORNIA AND THE WELL RECORD FOR 1915 (a)

Field.	Rigs Completed during Year.	Wells.		Production.	
		Completed during Year.	Abandoned during Year.	For Year.	Per Day.
Kern River	15	11	....	8,034,974	22,013
McKittrick	6	2	4	3,552,801	9,734
Midway-Sunset	120	124	9	39,318,093	107,721
Lost Hills-Belridge	33	15	5	4,318,550	11,832
Coalinga	7	13	9	13,548,159	37,118
Lompoc and Santa Maria	13	6	3	4,536,840	12,430
Ventura County and Newhall	19	12	2	1,036,305	2,839
Los Angeles and Salt Lake	....	....	....	2,110,133	5,781
Whittier-Fullerton	65	56	....	13,030,549	35,700
Summerland	....	....	....	53,000	145
Watsonville	1	1	2	27,375	75
Totals	279	240	34	89,566,779	245,388

(a) *Standard Oil Bulletin*, January, 1916, p. 11.

Total crude oil stocks, Dec. 31, 1914	58,526,274 bbl.
Total crude oil stocks, Dec. 31, 1915	57,147,051 bbl.
Decrease during year	1,379,223 bbl.
Daily decrease during year	3,779 bbl.

The completions in the older California fields show a heavy decline, as shown by the following table:

COMPLETIONS FOR THE YEARS 1912–1915

Field.	1912.	1913.	1914.	1915.
Coalinga	142	64	30	13
Kern River	94	33	15	11
Lompoc-Santa Maria	23	16	6	6
Total	259	113	51	30

Illinois.—Illinois has felt the steadying and helpful influence of an efficient State geological survey. It has aided not only in pointing out likely places for prospecting, but equally in discouraging wildcatting in absolutely hopeless territory. As a result, the State, having passed the maximum production from present pools, is certainly making the best of the conditions and declining more slowly than is usual at this stage.

ILLINOIS OIL PRODUCTION, 1906–1914

Year.	Barrels.	Value.
Previous	187,660	$116,561
1906	4,397,050	3,274,818
1907	24,281,973	16,432,947
1908	33,686,238	22,649,561
1909	30,898,339	19,788,864
1910	33,143,262	19,669,383
1911	31,317,038	19,734,339
1912	28,601,308	24,332,605
1913	23,893,899	27,432,000
1914	21,919,749	25,426,179
1915	19,041,695	18,655,850
Total	251,368,211	$197,513,107

FLUCTUATIONS IN PRICES, PER BARREL, OF ILLINOIS OIL IN 1914 AND 1915

1914. Date.	Price per Bbl.	1915. Date.	Price per Bbl.
Jan. 1	$1.45	Jan. 1	$0.89
Apr. 18	1.40	Feb. 16	0.84
Apr. 28	1.35	Aug. 12	0.89
May 1	1.27	Aug. 20	0.94
May 5	1.24	Aug. 23	0.99
May 12	1.21	Sept. 4	1.04
June 13	1.16	Sept. 15	1.09
Aug. 1	1.11	Sept. 27	1.12
Aug. 7	1.06	Oct. 5	1.17
Sept. 14	1.01	Oct. 23	1.27
Sept. 23	0.96	Nov. 15	1.32
Oct. 26	0.93	Nov. 17	1.37
		Dec. 3	1.42

Indiana.—Only the Sullivan County pool delayed the State's decline in oil production, although prospecting was fairly responsive to rising prices, and the future conditions will doubtless follow the course of Pennsylvania and New York.

PRODUCTION AND VALUE OF PETROLEUM IN INDIANA, 1903–1914 (a)
(In barrels)

Year.	Quantity.	Value.
1903	9,186,411	$10,471,127
1904	11,339,124	12,235,674
1905	10,964,247	9,404,909
1906	7,673,477	6,770,066
1907	5,128,037	4,536,930
1908	3,283,629	3,203,883
1909	2,296,086	1,997,610
1910	2,159,725	1,568,475
1911	1,695,289	1,228,835
1912	970,009	885,975
1913	956,095	1,279,226
1914	1,335,456	1,548,042
1915	875,758	813,395

(a) Statistics of U. S. Geol. Surv.

Kansas.—Two pools, the Augusta and the Eldorado, were developed to the west of the previous producing regions. Both found gas and oil at shallow depths which allowed of profitable wells at low drilling cost. Production declined slightly, as shown in the tables for the United States.

The production of Kansas from 1909 to 1915, inclusive, is as follows:

Year.	Production in Bbl. of 42 Gal. (a)	Percentage, Increase.
1909	1,263,764	....
1910	1,128,668	−10.7
1911	1,278,819	11.7
1912	1,592,796	24.5
1913	2,375,029	49.1
1914	3,103,585	30.7
1915	2,823,487	−12.97

(a) U. S. Geol. Surv. Statistics.

Kentucky and Tennessee.—No considerable change in production need be expected in Kentucky with the careful and experienced drilling in the old fields in the eastern part of the State, and the western development will go slowly until large capital is induced to make such a thorough geological study as that which Mr. J. H. Gardiner made in Ohio County with good results. A similar policy will be necessary before the oil resources of Tennessee can be estimated. This will be surely brought about as the price of crude eventually advances.

WELL RECORD FOR KENTUCKY FROM 1909 TO 1915, INCLUSIVE

Year.	Completions.	Initial Production, Bbl.	Dry Holes.	Gas Wells.
1910	121	829	50(a)	....
1911	136	1,822	33(a)	....
1912	178	1,943	61(a)	....
1913	210	2,215	74	3
1914	179	1,570	56	4
1915	92	728	36	....

(a) Gas wells not included.

FLUCTUATIONS IN PRICES, PER BARREL, OF SOMERSET AND RAGLAND, KY., OIL IN 1915

Date.	Somerset.	Ragland.
Jan. 1	$0.90	$0.70
Mar. 16	0.85	0.65
Mar. 20	0.83	....
Apr. 3	0.80	0.63
Aug. 13	0.90	....
Aug. 17	1.00	0.65
Aug. 24	1.03	....
Sept. 13	1.08	....
Sept. 27	1.12	....
Oct. 7	1.17	....
Oct. 27	1.22	....
Nov. 5	1.27	0.68
Nov. 15	1.32	0.70
Nov. 17	1.42	....
Dec. 3	1.50	....
Dec. 17	1.55	0.72
Dec. 30	1.63	0.75

Louisiana.—As in Texas, the Louisiana fields are sharply divided in the Gulf fields and those in northern Louisiana. There was the usual decline in the Gulf Region, in spite of an addition to the south of the Vinton pool. Edgerly doubled its production.

In northern Louisiana the Caddo pool showed little change, but a marked increase came from the Crichton pool on the east side of the Red River, in Abingdon parish. This effected a decided increase in the total of the State, and brings it up close to Illinois in the rank of oil producers. Much territory remains to be prospected in the State. Since the Louisiana State Conservation Commission began its work the waste of natural gas has greatly decreased.

FLUCTUATIONS IN PRICES, PER BARREL, OF LOUISIANA OIL IN 1915

Date.	DeSoto.	Caddo, 38° and Above.	Caddo, 35°.	Caddo, 32°.	Caddo, Heavy.	Vinton.	Jennings.	Crichton. (*a*)
Jan. 1	$0.80	$0.80	$0.60	$0.65	$0.45	$0.40	$0.40	$0.50
Feb. 18	0.70	0.70	....	0.55	....	....	....	....
Mar. 3	....	0.60	....	....	....	0.60	....	....
Mar. 24	0.60	0.50	0.50	0.45	....	....	....	....
Mar. 27	....	....	....	....	0.35	0.45	0.45	....
July 13	....	....	....	....	....	....	....	0.45
July 20	....	....	....	....	....	....	....	0.40
Aug. 27	0.65	0.55	0.55	0.50	0.40	....	....	....
Sept. 15	0.70	0.60	0.60	0.55	0.45	....	....	0.50
Sept. 22	0.75	0.65	0.65	0.60	0.50	....	....	0.55
Oct. 6	0.80	0.70	0.70	0.65	0.55	....	....	0.65
Nov. 18	0.90	0.80	0.80	0.75	0.65	....	....	0.75
Nov. 20	1.00	0.90	0.90	0.85	0.75	....	....	0.85
Dec. 17	1.10	1.00	1.00	0.95	0.80	....	....	....
Dec. 29	1.20	1.10	1.10	1.05	0.85	....	....	....

(*a*) On July 13 the production of Red River Parish, La., was classified as Crichton crude, and the price fixed at 45 cts., representing a decline of 5 cts.

Ohio.—In eastern Ohio intense search for high-grade oils was kept up. No sensational discoveries resulted, but the year was important in aiding the distribution of oil from Hocking County to Lake Erie and will greatly aid in maintaining oil and especially oil production in this belt in the future. With the gradual extension of the oil fields to the west the space between the eastern high-grade oil and the sulphur-bearing oils of northwestern oil is fast disappearing.

PRODUCTION OF OHIO BY DISTRICTS FOR THE LAST 12 YEARS

Year.	Lima Field.	Southeastern Ohio.	Mecca-Belden.	Total.
1904	13,350,060	5,526,146	425	18,876,631
1905	11,329,924	5,016,646	90	16,346,660
1906	9,881,184	4,906,399	180	14,787,763
1907	7,993,057	4,214,298	93	12,207,448
1908	6,748,676	4,109,935	186	10,858,797
1909	5,915,357	4,717,069	367	10,632,793
1910	5,094,136	4,822,193	41	9,916,370
1911	4,535,875	4,281,173	64	8,817,112
1912	(a)3,955,897	5,013,051	59	8,969,007
1913	(a)3,817,043	4,964,425	....	8,780,468
1914	(a)3,727,087	4,809,265	....	8,536,352
1915	3,393,833	4,431,493	....	7,825,326

(a) Includes Michigan. All production in barrels of 42 U. S. gal.
(b) U. S. Geol. Surv. statistics.

FLUCTUATIONS IN PRICES, PER BARREL, OF OHIO OIL IN 1915

Date.	North Lima.	South Lima.	Corning.	Wooster.
Jan. 1	$0.93	$0.88	$0.95	$1.15
Feb. 16	0.88	0.83	....	1.10
Mar. 20	....	....	0.90	....
Apr. 3	....	....	0.85	....
Apr. 17	....	....	0.83	1.05
Aug. 13	....	0.88	0.93	....
Aug. 17	....	....	1.03	....
Aug. 20	0.93	0.93	....	1.10
Aug. 23	0.98	0.98	....	1.15
Aug. 24	....	....	1.06	....
Sept. 4	1.03	1.03	....	1.20
Sept. 13	....	....	1.12	1.20
Sept. 15	1.08	1.08	....	1.25
Sept. 27	....	....	1.18	....
Oct. 7	....	....	1.25	....
Oct. 23	1.13	1.13	....	1.30
Oct. 27	....	....	1.30	....
Nov. 15	1.18	1.18	1.40	1.35
Nov. 17	1.23	1.23	....	1.38
Nov. 18	....	....	1.50	....
Dec. 3	1.28	1.28	1.60	1.43
Dec. 17	....	....	1.65	....
Dec. 30	....	....	1.75	....

Oklahoma.—At the beginning of 1915 the Cushing pool had been fully developed and in spite of the prolific Bartlesville sand from which it drew its supply, a decline was daily expected. Nevertheless, the production increased till April, when this pool alone yielded nearly 12,000,000 bbl. for the month. Even when the decline began it was slow, and it was late in the year when from a peak production of over 300,000 bbl. a day the output fell to below 90,000 bbl. a day, and then it rallied to over 100,000. As a result, the year's total for the State approximated 100,000,000 bbl., and established a new record for a State's output in any year. It is difficult to compare the output with that of previous years because of a necessary change in the method of stating the output. Up to 1914 it was satisfactory to use as the output of petroleum the amount sold by the producers to the pipe-lines, the railroads and to other transporting agencies, such as private pipe-lines to refineries. But the easy refining of Cushing crude led to erecting many small refineries owned and operated by the oil producers themselves. It was not the custom in previous years to include as marketed oil such oil as had not been sold but still remained in producers' storage. But in 1914 and 1915 much oil in Oklahoma never was sold as crude, but was refined by the producers. It was necessary to include this and it caused the true marketed production to considerably exceed the pipe-line runs. Not all the producers' storage is included as marketed, but merely that which was consumed.

The pipe-lines from the older producing regions in Oklahoma generally declined.

Toward the last of the year, attention was directed to the south end of the Cushing pool and with encouraging outlook for an important extension in that direction.

PRODUCTION AND VALUE OF PETROLEUM FROM OKLAHOMA SINCE 1909

Year.	Production, Bbl.	Value.
1909	47,859,218	$17,428,990
1910	52,028,718	19,992,660
1811	56,069,637	26,451,767
1912	51,427,071	34,672,604
1913	63,579,384	59,581,948
1914	73,631,724	57,253,187
1915	97,915,243	56,706,133

FLUCTUATIONS IN PRICES, PER BARREL, OF KANSAS AND OKLAHOMA, AND HEALDTON, OKLA., OIL FOR 1915

Date.	Kansas and Oklahoma.	Healdton, Okla.
Jan. 1	$0.55	$0.50
Feb. 2	....	0.30
Feb. 8	0.45	....
Feb. 15	0.40	....
Aug. 2	0.50	....
Aug. 4	0.55	....
Aug. 11	0.60	....
Aug. 19	0.65	....
Aug. 21	0.75	....
Sept. 11	0.80	....
Sept. 24	....	0.35
Oct. 11	....	0.40
Oct. 25	....	0.45
Nov. 13	0.90	....
Nov. 15	1.00	0.55
Dec. 13	1.10	....
Dec. 14	1.20	....

The refining developments in Oklahoma have been well described by Mr. H. G. James.[1] He shows that the flood of gasoline from Cushing oil brought refineries there by the score and reduced the price "below that for good drinking water." During the first part of 1915 lower grades

[1] *Oil and Gas Journal*, Jan. 13, 1916.

of gasoline sold for 5 cts. per gal. With the decline of the Cushing supply refineries which had flocked to the Cushing field were compelled to practise economies and improve to a degree which was most helpful to refining technology. These independent refiners were prompt then to raise the price as the supply became insufficient.

The most important technical progress in the State has been the work of the Bureau of Mines in demonstrating to the general satisfaction of the oil producers that the natural gas above prolific oil sands can be conserved by the use of mud-laden fluid.

WELL RECORD FOR OKLAHOMA FOR 1915, BY MONTHS

Month.	Comp.	Prod.	Dry.	Gas.
January	292	123,504	55	24
February	293	117,558	50	20
March	284	85,025	63	27
April	324	146,026	52	32
May	275	126,360	38	22
June	276	114,370	39	18
July	263	76,420	44	13
August	285	48,798	55	14
September	292	24,525	76	36
October	485	61,227	80	40
November	708	62,453	159	50
December	826	48,429	135	54
Total, 1915	4,603	1,034,965	846	350
Total, 1914	8,297	973,550	1,324	529
Difference	−3,694	+61,145	−478	−179

Pennsylvania and New York.—Under the stimulating effect of rising prices every effort was made to extract more oil from the old pools of Pennsylvania and New York, and even without actually increasing the total product over that of the previous year it was important to find that the normal decrease could be practically checked by cleaning out old wells, or by plugging lower levels to return to sands originally neglected, by better pumping facilities and by the introduction of compressed air into a central well and thereby forcing oil into surrounding wells. This method has been successful also in eastern Ohio and West Virginia.

RESULTS OF FIELD OPERATIONS IN NEW YORK AND PENNSYLVANIA, 1915
(New York and Northwest Pennsylvania)

	Comp.	Prod.	Dry.	Gas.
Allegheny	92	109	3	23
Bradford	348	1,018	11	24
Middle Field	175	353	14	9
Venango-Clarion	590	634	64	70
Butler-Armstrong	323	4,218	83	16
Total	1,528	6,332	175	142
Total, 1914	2,249	4,464	208	171
Difference	721	1,868	33	29

A few new discoveries were noted in Butler and Allegheny Counties. They were not significant as money makers, and the resulting speculative investment was disastrous.

PRODUCTION AND VALUE OF PETROLEUM IN PENNSYLVANIA, 1904-1915

Year.	Quantity, Bbl.	Value.
1904	11,125,762	$18,222,242
1905	10,437,195	14,653,278
1906	10,256,893	16,596,943
1907	9,999,306	17,579,706
1908	9,424,325	16,881,194
1909	9,299,403	15,424,554
1910	8,795,662	11,908,914
1911	8,248,158	10,894,074
1912	7,837,948	12,886,752
1913	7,963,282	19,805,452
1914(*a*)	8,170,335	15,573,822
1915	7,838,705	12,431,353

(*a*) U. S. Geol. Surv. statistics.

FLUCTUATIONS IN PRICES, PER BARREL, OF PENNSYLVANIA, CABELL, MERCER, BLACK AND NEW CASTLE OIL IN 1915

Date.	Pennsylvania.	Cabell.	Mercer Black.	Newcastle.
Jan. 1	$1.50	$1.10	$1.07	$1.05
Mar. 16	1.45	1.05	1.02	1.02
Mar. 20	1.40	1.00	1.00	1.00
April 3	1.35	0.97	0.97	0.97
Aug. 13	1.45	1.07	1.07	1.07
Aug. 17	1.55	1.17	1.17	1.17
Aug. 24	1.60	1.20	1.20	1.20
Sept. 13	1.65	1.25	1.23	1.23
Sept. 27	1.70	1.30	1.26	1.26
Oct. 7	1.75	....	....	....
Oct. 27	1.80	1.35	1.30	1.30
Nov. 5	1.85	1.40	1.35	1.35
Nov. 15	1.90	1.45	1.40	1.40
Nov. 18	2.00	1.55	1.50	1.50
Dec. 3	2.10	1.65	1.60	1.60
Dec. 17	2.15	1.70	1.65	1.65
Dec. 30	2.25	1.78	1.75	1.75

Texas.—Deep drilling in the Humble pool and continued success in the Sour Lake district increased the yield of the Gulf region and much more than offset the decline in the Electra, Eeds, Burkburnett and Petrolia fields in north Texas. The Strawn pool in Palo Pinto County, the Thrall pool in Williamson County, the Bland pool in Orange County and the Alta Vista pool, near San Antonio, Bexar County, were new finds which are likely to have interesting development in 1916.

FLUCTUATIONS IN PRICES, PER BARREL, OF COASTAL TEXAS OIL IN 1915

Date.	Humble.	Saratoga.	Sour Lake.	Spindle-top.	Batson.	Dayton.	Goose Creek.	Mark-ham.
Jan. 1	$0.35	$0.40	$0.40	$0.40	$0.40	$0.30	$0.40	$0.40
Mar. 3	0.55	0.60	0.65	0.60	....	....	....	....
Mar. 27	0.45	0.45	0.45	0.45	0.45	0.40	0.50	0.50
July 23	0.50	....	0.50	....	....	....	....	....
Dec. 10	....	0.50	....	....	0.50	0.50	....	....

FLUCTUATIONS IN PRICES, PER BARREL, OF NORTH TEXAS AND PANHANDLE OIL IN 1915

Date.	Thrall.	Strawn.	Moran.
Jan. 1	$0.40	$0.40	$0.70
Aug. 6	0.55	0.55	....
Aug. 13	0.60	0.60	....
Aug. 26	0.65	0.65	....
Sept. 10	0.70	0.70	....
Sept. 16	0.75	0.75	0.75
Nov. 15	0.95	0.95	0.95
Dec. 14	1.05	1.05	1.05

West Virginia.—Prospecting for oil was almost stopped by the depression in price of crude early in the year, but became more active than ever as prices rose late in the year. Many new wells were drilled, the new work being chiefly in Kanawha and Wetzel Counties. The results were not as good as for corresponding work in 1914, and no exceptional discoveries were made sufficient to maintain the product of 1914.

PRODUCTION AND VALUE OF PETROLEUM IN WEST VIRGINIA, 1903–1914 (*a*)
(In barrels)

Year.	Quantity.	Value.
1903	12,899,395	$20,516,532
1904	12,644,686	20,583,781
1905	11,578,110	16,132,631
1906	10,120,935	16,170,293
1907	9,095,296	15,852,428
1908	9,523,176	16,911,865
1909	10,745,092	17,642,283
1910	11,751,871	15,723,544
1911	9,792,324	12,767,293
1912	12,126,137	19,927,721
1913	11,562,730	28,828,814
1914	9,680,033	18,468,540
1915	9,264,798	14,468,278

(*a*) Statistics of the U. S. Geological Survey.

Wyoming.—Active development has characterized every branch of Wyoming's oil industry. The development of new oil territory includes the Elk Basin, Grass Creek, Pine Dome, Saddle Rock, Greybull and Big Muddy oil fields. With this has come the necessary development of transportation of crude oil to refining centers. Again, the refining capacity of the State has more than kept pace with the other developments.

Only a few years ago the Wyoming oil producers besought the Eastern consuming oil interests to provide pipe-line facilities for carrying the crude oil away from the State. They met with no encouragement, because the considerable extent of Wyoming's oil resources was not believed. The oil producers were therefore forced to develop refining at home. Three companies, the Midwest, Franco-American and Natrona, began refining at Casper, the nearest town to the principal field at Salt Creek, 50 miles to the north. This was the most fortunate feature of Wyoming's oil development. As a result the total revenue obtained within the State for the oil products is probably as great as for the entire product of Mexico, where the output is several times as great.

The refining interests at Casper and at Greybull have now united as the Midwest Refining Co. and the Greybull Refining Co. Two pipelines connect the Salt Creek fields with Casper, while the refinery at Greybull takes care of much of the production in the northwestern part of the State.

In addition, the Standard Oil Co. of Indiana, finding it possible to make good motor spirits from the heavy distillates from Salt Creek crude have developed a large plant for cracking the heavy wax distillate into motor spirits by the Burton process. At present 50 Burton units are in operation and foundations are in place for 30 more of the newer tubular modification of this same process. The supply of wax oil and some fuel oil is bought from the Midwest Refining Co. and piped to the new cracking stills. After conversion into motor spirits it is sold again to the Midwest Co. and finished and marketed by them.

This cracking plant is very successful as to the grade of motor spirits they turn out, and a ready sale is found for it over a large territory, including Canada.

The refining capacity of the Midwest Co. includes three establishments, each complete in itself for the distillation of crude oil into gasoline, kerosene, wax oil, fuel-oil distillates and fuel residuum, which is sold to the Northwestern and Burlington Railroad systems. The total capacity is over 25,000 bbl. per day. The technologic improvements in the refining system include six continuous tower steam stills, by which the gasoline output has been doubled in the last 6 months. Another interesting equipment consists of 12 stills, all working together as one continuous system of 12 stages. By this the crude is separated continuously into various grades of gasoline, burning oil, heavy distillate, wax oil and residuum. In October of 1915 a contract was signed with the Bureau of Mines for the development of the Rittman process of cracking heavy oils into gasoline. Since then the first unit of the "Midwest system" of the Rittman process has been building and is now (June, 1916) nearly ready to operate. The unit includes six cracking tubes, each 18 ft. by 8 in. diameter, installed in one furnace, where each tube can be operated independently of the others if desired. It also includes a system of six heat exchangers by which the gasoline is continuously separated from the uncracked oil.

The Rittman process differs in many mechanical respects from the Burton process, and, in principle, by cracking oils only in the vapor stage instead of in both liquid and vapor stage as in the Burton process.

WORLD'S MARKETED PRODUCTION OF CRUDE PETROLEUM, 1857–

Year.	Roumania.	U. S. A.	Italy.	Canada.	Russia.	Galicia.	Japan.[2]	Germany.
1857	1,977	...	...	...	...	...	...	...
1858	3,500	...	...	...	...	...	...	...
1859	4,349	2,000	...	...	...	...	...	...
1860	8,542	500,000	36	...	...	...	...	...
1861	17,279	2,113,009	29	...	...	...	...	...
1862	23,198	3,056,690	29	11,755	...	...	...	...
1863	27,943	2,611,309	58	82,814	40,816	...	...	...
1864	33,013	2,116,109	72	90,000	64,586	...	...	...
1865	39,017	2,497,700	2,265	110,000	66,542	...	...	...
1866	42,534	3,597,700	992	175,000	83,052	...	...	...
1867	50,838	3,347,300	791	190,000	119,917	...	...	...
1868	55,369	3,646,117	367	200,000	88,327	...	...	...
1869	58,533	4,215,000	144	220,000	202,308	...	...	...
1870	83,765	5,260,745	86	250,000	204,618	...	...	...
1871	90,030	5,205,234	273	269,397	165,129	...	...	...
1972	91,251	6,293,194	331	308,100	184,391	...	...	...
1873	104,036	9,893,786	467	365,052	474,379	...	...	...
1874	103,177	10,926,945	604	168,807	583,751	149,837	...	...
1875	108,569	8,787,514	813	220,000	697,364	158,522	4,566	...
1876	111,314	9,132,669	2,891	312,000	1,302,528	164,157	7,708	...
1877	108,569	13,350,363	2,934	312,000	1,800,720	169,792	9,560	...
1878	109,300	15,396,868	4,329	312,000	2,400,960	175,420	17,884	...
1879	110,007	19,914,146	2,891	575,000	2,761,104	214,800	23,457	...
1880	114,321	26,286,123	2,035	350,000	3,001,200	229,120	25,497	...
1881	121,511	27,661,238	1,237	275,000	3,601,441	286,400	16,751	9,310
1882	136,610	30,349,897	1,316	275,000	4,537,815	330,076	15,549	29,219
1883	139,486	23,449,633	1,618	250,000	6,002,401	365,160	20,473	58,025
1884	210,667	24,218,438	2,855	250,000	10,804,577	408,120	27,923	26,708
1885	193,411	21,858,785	1,941	250,000	13,924,596	465,400	29,237	46,161
1886	168,606	28,064,841	1,575	584,061	18,006,407	305,884	37,916	41,360
1887	181,907	28,283,483	1,496	525,655	18,367,781	343,832	28,645	73,864
1888	218,576	27,612,025	1,251	695,203	23,048,787	466,537	37,436	74,284
1889	297,666	35,163,513	1,273	704,690	24,609,407	515,268	52,811	84,782
1890	383,227	45,823,572	2,998	795,030	28,691,218	659,012	51,420	68,217
1891	488,201	54,292,655	8,305	755,298	34,573,181	630,730	52,917	108,296
1892	593,175	50,514,657	18,321	779,753	35,774,504	646,220	68,901	108,929
1893	535,655	48,431,066	19,069	798,406	40,456,519	692,669	106,384	101,404
1894	507,255	49,344,516	20,552	829,104	36,375,428	940,146	171,744	99,390
1895	575,200	52,892,276	25,843	726,138	46,140,174	1,452,999	141,310	122,564
1896	543,348	60,960,361	18,149	726,822	47,220,633	2,443,080	197,082	121,277
1897	570,886	60,475,516	13,892	709,857	54,399,568	2,226,368	218,559	145,061
1898	776,238	55,364,233	14,489	758,391	61,609,357	2,376,108	265,389	165,745
1899	1,425,777	57,070,850	16,121	808,570	65,954,968	2,313,047	536,079	183,427
1900	1,628,535	63,620,529	12,102	913,498	75,779,417	2,346,505	866,814	192,232
1901	1,678,320	69,389,194	16,150	756,679	85,168,556	3,251,544	1,110,790	358,297
1902	2,059,935	88,766,916	18,933	530,624	80,540,044	4,142,159	1,193,038	313,630
1903	2,763,117	100,461,337	17,876	486,637	75,591,256	5,234,475	1,209,371	353,674
1904	3,599,026	117,080,960	25,476	552,575	78,536,655	5,947,383	1,419,473	445,818
1905	4,420,987	134,717,580	44,027	634,095	54,960,270	5,765,317	1,472,804	637,431
1906	6,378,184	126,493,936	53,577	569,753	58,897,311	5,467,967	1,710,768	560,963
1907	8,118,207	166,095,335	59,875	788,872	61,850,734	8,455,841	2,001,838	578,610
1908	8,252,157	178,527,355	50,966	527,987	62,186,447	12,612,295	2,070,145	756,631
1909	9,327,278	183,170,874	42,388	420,755	65,970,350	14,932,799	1,889,563	1,009,278
1910	9,723,806	209,557,248	50,830	315,895	70,336,574	12,673,688	1,930,661	1,018,837
1911	11,107,450	220,449,391	74,709	291,096	66,183,691	10,519,270	1,658,903	1,032,522
1912	12,976,232	222,935,044	53,778	243,336	68,019,208	8,535,174	1,671,405	1,017,045
1913	13,554,768	248,446,230	47,256	228,080	62,834,356	7,818,130	1,942,009	1,031,050
1914	12,826,579	265,762,535	(a)39,548	214,805	67,020,522	(a)5,033,350	2,738,378	(a)995,764
1915[1]	12,650,000	281,104,104	50,000	250,000	69,000,000	9,000,000	2,840,000	(a)995,764
Total	130,632,474	3,616,561,244	852,229	23,743,610	1,691,233,845	139,873,601	29,891,158	900,000
								13,865,569

[1] Estimates. [2] and Formosa. (a) Estimated.

1915 BY YEARS AND BY COUNTRIES, IN BARRELS OF 42 GAL.

India.	Dutch E. Ind.	Peru.	Mexico.	Trinidad.	Egypt.	All Other.	Total.	Year.
...	...	...	...	...	...	...	1,977	1857
...	...	...	...	...	...	...	3,560	1858
...	...	...	...	...	...	...	6,349	1859
...	...	...	...	...	...	...	508,578	1860
...	...	...	...	...	...	...	2,130,917	1861
...	...	...	...	...	...	...	3,091,692	1862
...	...	...	...	...	...	...	2,762,940	1863
...	...	...	...	...	...	...	2,303,780	1864
...	...	...	...	...	...	...	3,715,524	1865
...	...	...	...	...	...	...	3,899,278	1866
...	...	...	...	...	...	...	3,708,846	1867
...	...	...	...	...	...	...	3,990,180	1868
...	...	...	...	...	...	...	4,695,985	1869
...	...	...	...	...	...	...	5,799,214	1870
...	...	...	...	...	...	...	5,730,063	1871
...	...	...	...	...	...	...	6,877,267	1872
...	...	...	...	...	...	...	10,837,720	1873
...	...	...	...	...	...	...	11,933,121	1874
...	...	...	...	...	...	...	9,977,348	1875
...	...	...	...	...	...	...	11,051,267	1876
...	...	...	...	...	...	...	15,753,938	1877
...	...	...	...	...	...	...	18,416,761	1878
...	...	...	...	...	...	...	23,601,405	1879
...	...	...	...	...	...	...	30,017,606	1880
...	...	...	...	...	...	...	31,992,797	1881
...	...	...	...	...	...	...	35,704,288	1882
...	...	...	...	...	...	...	30,255,479	1883
...	...	...	...	...	...	...	35,968,741	1884
...	...	...	...	...	...	...	36,764,730	1885
...	...	...	...	...	...	...	47,243,154	1886
...	...	...	...	...	...	...	47,807,083	1887
...	...	...	...	...	...	...	52,164,597	1888
94,250	...	...	...	...	...	...	61,507,095	1889
118,065	...	...	...	...	...	...	76,632,838	1890
190,131	...	...	...	...	...	...	91,100,347	1891
242,284	...	...	...	...	...	...	88,739,219	1892
298,969	600,000	...	...	...	...	...	92,038,127	1893
327,218	688,170	...	...	...	...	...	89,335,697	1894
371,536	1,215,757	...	...	...	...	...	103,562,510	1895
429,979	1,427,132	47,536	...	...	...	...	114,159,183	1896
545,704	2,551,649	70,831	...	...	...	...	121,948,575	1897
542,110	2,964,035	70,905	...	...	...	...	124,924,682	1898
940,971	1,795,961	89,166	...	...	...	...	131,143,742	1899
1,078,264	2,253,355	274,800	...	...	...	...	149,132,116	1900
1,430,716	4,013,710	274,800	...	...	...	(*a*)20,000	167,424,089	1901
1,617,363	2,430,465	286,725	...	...	...	(*a*)26,000	181,965,876	1902
2,510,259	5,770,056	278,092	...	...	...	(*a*)36,000	194,804,294	1903
3,385,468	6,508,485	345,834	220,653	...	...	(*a*)40,000	218,299,419	1904
4,137,098	7,849,896	447,880	320,379	...	...	(*a*)30,000	215,361,296	1905
4,015,803	8,180,657	536,294	1,097,264	...	...	(*a*)30,000	214,010,124	1906
4,344,162	9,982,597	756,226	1,717,690	...	...	(*a*)30,000	264,958,008	1907
5,047,038	10,283,357	1,011,180	3,481,610	169	...	(*a*)30,000	285,089,984	1908
6,676,517	11,041,852	1,316,118	2,488,742	57,143	...	(*a*)20,000	298,373,216	1909
6,137,990	11,030,620	1,330,105	3,332,807	142,857	...	(*a*)20,000	327,615,603	1910
6,451,203	12,172,949	1,368,274	14,051,643	285,307	9,150	(*a*)45,000	345,685,081	1911
7,116,672	10,845,624	1,751,143	16,558,215	436,805	205,905	(*a*)105,000	352,484,591	1912
7,930,149	11,966,857	2,133,261	25,902,439	503,616	94,635	(*a*)270,000	384,667,550	1913
(*a*)8,000,000	(*b*)12,705,208	1,917,802	21,188,427	643,533	777,038	(*c*)620,000	400,483,489	1914
8,500,000	12,800,000	3,500,000	35,500,000	700,000	800,000	1,500,000	439,094,104	1915
82,479,919	151,078,392	17,806,972	125,859,869	2,769,430	1,886,728	1,822,000	6,032,357,040	bbl.

(*b*) Includes British Borneo. (*c*) Includes 600,000 bbl. produced in Argentina.

Petroleum in Foreign Countries

Canada.—The total production of crude petroleum as determined by the Canadian Bureau of Mines increased slightly, from 212,497 bbl. in 1914 to 214,442 bbl. in 1915. The fact that the usual decline was more than checked is made more interesting by the fact that it was due to cleaning out and deepening the old wells of Ontario in the Lambton region that has been productive for over half a century. This was greatly stimulated by an average gain in price from $1.28 to $1.68 per bbl. The new developments near Calgary in Alberta continue in the speculative stage and had no effect upon the statistics. Railroad facilities may be completed to the tar sands of the Athabasca region during this year, and will greatly stimulate efforts to develop an oil field there.

A small refinery has been planned for refining the Alberta product at Sandstone, near Okotoks.

Mexico.—It is estimated that the potential capacity of the Mexican oil fields is 600,000 bbl. of oil per day. The actual output depends upon the ability to sell the product and this in turn is limited chiefly by the transportation facilities. With such a condition it was inevitable that the product in 1915 should increase over 1914 in spite of civil war and restricting decrees by the constitutional government. In 1914 21,188,427 bbl. was produced. This increased in 1915. Of the total amount about 24,000,000 bbl. was marketed, chiefly to the United States and the balance increased the stocks in steel storage.

PRODUCTION OF PETROLEUM IN MEXICO, 1908 TO 1915 INCLUSIVE

Year.	Production in Barrel.
1908	3,481,410
1909	2,488,742
1910	3,332,807
1911	14,051,643
1912	16,588,215
1913	25,902,439
1914	21,188,427
1915	....

Drilling was not active during the year. What was done served to emphasize the importance of the southern portion of the field, and in the spring of 1916 probably the largest gusher in the world was brought in at Cerro Azul by the Huasteca Oil Co. (Doheny interests).

It is remarkable that by far the greater portion of the production came from the southern field and, in fact, from the two monster wells of the Aguila and Huasteca Cos. and from a new 10,000-bbl. well of the Penn-Mex Co. The success of the deep-sea loading scheme increased the output from Tuxpam bar, and Tampico declined slightly as an oil port. A significant feature of the exports was delivery of over 1,000,000 bbl. to South American ports.

In the northern fields, Panuco yielded a second large gusher estimated at over 60,000 bbl. a day. It was drilled to offset the Corona gusher on the adjoining lease. It found the sand over 300 ft. lower than in the Corona well, showing a sharp southeasterly dip to the producing sand.

South America

Argentina.—Production has reached 400,000 bbl. a year from the heavy oil produced at Commodoro Rivadavia from lands chiefly owned by the Government. Recently the government board in charge of administering the oil lands has shown much more activity and has obtained an appropriation of $6,000,000 for oil-well drilling. Four drilling machines of the Holland system have been purchased, and the product should be doubled during 1916. This is greatly desired, as motor fuel is scarce. It is imported in the forms of ordinary gasoline and engine distillate of 44° Bé. gravity. The imported product is expensive and is subjected to a 20 per cent. tax.

Colombia.—The petroleum deposits of Colombia continue to attract attention from capitalists. The only active exploration work is being done by the Standard Oil Co. in the Sinu region, but numerous other syndicates, principally from the United States, have recently sent investigators into this country.

Petroleum seepages, heretofore unrecorded, have been found in all the Departments bordering on the Magdalena River as far south as Girardot, where the railway connects the steamboat traffic of the river with Bogota. In the Magdalena Basin some optional contracts have been taken, which, if made operative, will call for the commencement of active boring operations on the lands during the next 18 months. In most of these cases the names of the principals have been reserved.

Guatemala.—The government of Guatemala has taken measures to retain exclusive control of the oil deposits of that country. A presidential decree in a recent number of *El Guatemalteco* specified that deposits of oil and hydrocarbons may be acquired or worked in no other way than by lease from the government for terms of not more than 10 years, and such leases will be made only to native or naturalized Guatemalans.

Peru.—Production increased satisfactorily in Peru during 1915, with an outlook for more important developments in 1916.

The government's acceptance of the tax of 1s. per ton on petroleum exports instead of 2.4 and 8s. previously demanded on production insures that the active development policy inaugurated by the Imperial Oil Co. at Talara and Negritos will be carried forward. The new refinery at Talara, when completed, will have a capacity of 4000 bbl. a day and it is intended to make Talara the distributing point for the entire West Coast of South America. It is estimated that the new tax will amount to a levy of 10 per cent. per annum on the net profits of the Negritos fields. Exports from Negritos during the year 1914–1915 amounted to 219,000 tons and this figure will be largely increased during the present year.

Trinidad.—According to Consul Andrew J. McConnico, there have been noteworthy developments in the oil industry of Trinidad, British West Indies, during the past year.

The United British West Indies Petroleum Syndicate at Point Fortin is ready to supply oil fuel under contract, and several such contracts have been closed. Lately seven ocean vessels have called to replenish their supply of oil fuel, obtained from this company. Only a few weeks ago a well was sunk which proved to be very valuable.

The Trinidad Leaseholds (Ltd.) another large company, is at present actively engaged in laying pipe-lines for the transportation of its oils from the Morne L'Enfer reserve via Fyzabad to Pointe-a-Pierre, near San Fernando, where a pier 300 ft. long has already been constructed. The harbor at this point is very suitable for the anchorage of ocean vessels while obtaining supplies of oil fuel.

The Central Oilfield (Ltd.), at Tabaquite, is largely interested in refining the oils at this place, which have a paraffin basis. It ships regularly to points in British Guiana and the West Indies, besides supplying some local consumption.

The fuel-oils produced in Trinidad are being used to some extent by the British Admiralty, filling all the necessary requirements, and within the last year the use of the oils locally for fuel purposes has made some advances. A few of the larger sugar factories have installed oil-burning appliances, and the Trinidad Electric Co. (Ltd.), which supplies power and light to the tramway company and electric-lighting company of Port of Spain, is now converting its boilers and plant to use fuel-oil instead of coal. The Trinidad Government Railway is making trials of oil in its locomotives. So far the tests have proved quite satisfactory, and it is likely that in the near future the whole system will be operated by fuel-oil instead of patent fuel. Some of the smaller Government boats and a number of privately owned vessels plying the Gulf of Paria are soon to be equipped with oil-burning machinery. Already some of the smaller power plants of the city have secured such equipment, and have found the cost of operation decidedly less than when using coal.

The introduction of oil-burning machinery in this colony is due largely to the efforts of Alexander S. Hay, an American mechanical engineer. The increasing price of coal is also responsible, fuel-oil being more economical. Throughout the colony, in fact, coal, except for bunkering purposes, is likely to be entirely superseded by fuel-oil; and with Trinidad leading the way it is likely that other British colonies will follow.

The Brighton Oil Co. remains in the forefront in oil production, and ships crude oil to the United States regularly. Much of the machinery for this and the other companies mentioned is imported from the United States, and all of the oil-burning equipment now being installed is of American manufacture.

According to figures issued by the chamber of commerce of Port of Spain, the quantities of petroleum shipped up to Nov. 15 of each of the years mentioned was as follows: 1913, 12,138,734 gal.; 1914, 12,002,748 gal.; and 1915, 9,704,453 gal.

Europe

Roumania.—Even if, in spite of the war, the production of oil in Roumania has practically maintained the figures for the corresponding period of 1914, this can not be said as regards the refining activity during the same period, says the *Petroleum Review.* While the production of crude oil in the country during the first 6 months of the year amounted to 906,472 tons, as against 878,516 tons during the corresponding period of 1914, the refining industry during the same period considerably diminished. During the first 6 months of 1914 there were treated in the refineries 880,143 tons of crude oil—that is to say, a quantity exceeding the production obtained during that period. During the 6 months of this year there were treated 757,870 tons of crude oil, which quantity is less than the actual production by 148,602 tons, or, in other words, amounts to but 83.5 per cent. of the total production, as against over 100 per cent. treated during the corresponding period of last year.

PRODUCTION OF PETROLEUM IN ROUMANIA IN 1915, BY MONTHS, COMPARED WITH 1914

	1914, Metric Tons.	1915, Metric Tons.
January	139,974	168,811
February	132,473	138,286
March	161,833	162,408
April	147,975	150,716
May	147,486	149,738
June	148,775	136,605
July	148,905	134,457
August	137,220	128,808
September	129,517	128,854
October	161,247	135,003
November	147,884	126,169
December	180,037	113,290
Total	1,783,947	1,673,145

The cause of this state of affairs lies, naturally, in the difficult situation created for the Roumanian industry by the present events, and especially by the total closing of the waterways by which under normal circumstances 90 per cent. of the Roumanian exports are made. The exportation by land, which the Roumanian industry has managed to organize with enormous difficulty, can not absorb all the products obtained in the refineries. On the other hand, a certain number of products are totally prohibited for export. All this has resulted in the stocks in the refineries and export installations accumulating very rapidly, and this, in its turn, has rendered impossible the continuation of the refining industry to the full capacity of the refineries.

PETROLEUM PRODUCTS MANUFACTURED IN ROUMANIA IN 1914 AND 1915
(In metric tons)

Months.	Total Crude Petroleum Used in Manufacture.	Petroleum Products during 1914.				
		Gasoline.	Kerosene.	Lubricating Oil.	Residuals.	Total Products.
January	138,612	32,158	30,929	4,218	69,131	136,436
February	134,685	32,302	28,366	4,566	67,339	132,573
March	148,552	36,708	30,009	6,798	73,187	146,792
April	146,483	32,173	35,475	8,746	68,541	144,935
May	168,138	40,274	36,448	12,857	76,554	166,133
June	143,673	34,425	29,585	10,643	67,583	142,236
July	143,287	32,487	33,228	9,219	66,375	141,309
August	138,808	32,184	28,508	6,236	69,947	138,875
September	129,668	28,722	26,071	8,007	64,163	126,963
October	141,783	34,408	28,946	8,069	68,115	139,538
November	117,973	28,839	21,570	8,289	57,078	115,776
December	129,232	32,185	23,457	12,399	59,263	127,304
Totals	1,680,894	396,865	352,682	100,047	807,276	1,656,870
		Petroleum Products during 1915.				
January	143,552	37,079	27,599	11,330	65,723	141,731
February	95,998	22,968	16,640	9,007	45,847	94,462
March	115,530	30,073	17,841	9,523	56,279	113,716
April	127,977	32,349	22,232	10,651	60,123	125,355
May	132,160	32,737	22,771	7,246	66,970	129,724
June	142,653	34,968	22,681	12,462	70,142	140,253
July	149,117	37,271	25,393	13,046	70,826	146,536
August	150,655	36,711	23,803	14,690	72,830	148,034
September	134,791	33,050	20,498	12,242	66,525	132,315
October	131,092	32,491	21,670	8,689	65,912	128,762
November	126,843	32,087	21,347	9,857	61,046	124,337
December	130,613	33,025	21,158	10,942	63,453	128,578
Totals	1,580,981	394,809	263,633	129,685	765,676	1,553,803

The average percentage of different products was as follows: Benzine, 23.6 per cent.; illuminating oil, 21.0 per cent.; lubricants, 5.9 (increase); residuum, 48 per cent., loss 1.5 per cent. This average yield varies only slightly from year to year, in Roumania.

Russia.—According to the *Torgovo-Promyshlennaya Gazetta* (Petrograd) the total output of petroleum in Russia in 1915 amounted to 572,000,000 poods (about 69,000,000 bbl. of 42 gal. at the United States Geological

Survey rate of 8.33 poods to the barrel), as compared with 557,000,000 poods (67,000,000 bbl.) in 1914.

The increase came largely from the Maikop field, where the product expanded from 3,956,606 poods in 1914 to 7,688,054 poods in 1915. The Grosny field, which had been increasing till last year, showed a decline of about 12 per cent. The Island of Tcheleken showed a similar decline. The Ural oil field remained stationary. The production of the old Baku field was stimulated by filling in over 100 acres of Bebi Eibat Bay. This work will be continued till over 500 acres are filled in and made available for drilling by the development of the Pula field 30 miles from Baku.

Asia

Japan.—The production of crude petroleum in Japan increased from 95,280,000 gal. in 1914 to 119,100,000 gal. in 1915. The increase came from the Akita district, where the product amounted to over 43,000,000 gal., double that of 1914, and from the Niitsu pool in the old Echigo district. The Nishiyama and Higashiyama fields declined markedly.

The total increase proved somewhat embarrassing, for there is not sufficient refining capacity for the increase, nor does the market at present admit of any great expansion. The Nippon Co. has ordered additional stills from Russia for installation at Kurokawa, while the Hoden Oil Co. is buying additional refining capacity in the United States. Prices have previously been held up by a convention. It is doubtful if this can be maintained. Stocks have increased and imports have declined.

Australasia

New Zealand.—According to Consul General Alfred A. Winslow, there are 15 borings for petroleum, varying from 1375 to 4040 ft. in depth, of which five are producing more or less crude oil. It seems to be the general impression that more and better oil can be found further down, and the New Zealand Government is encouraging its development.

The Director of Geological Survey in reporting to the minister of mines has the following to say about the future of the petroleum industry in this Dominion:

"Practically all qualified observers are agreed in the belief that the source of the New Plymouth oil is at a great depth, and that probably the principal oil horizon will not be found at a much less depth than 5000 ft. Clearly, then, 3000 ft. in depth will not be directly important in deciding whether Taranaki possesses a prolific oil field or not. They may, however, in places be moderately profitable, and may indirectly be of great value in furnishing the structural data of which at present there is so great a lack. The area most deserving of being prospected appears to be the strip of country that extends for 15 miles south-southeast from the Sugarloaves, and contains somewhat numerous gas vents. So far as can be judged from the data at present known, the first deep bore ought to be in the neighborhood of Moturoa, where a considerable amount of oil has already been obtained. Had the area to the south-southeast already mentioned been more thoroughly prospected by means of 2500 ft. to 3000 ft. bores, possibly this opinion would need modification."

The output to date has amounted to about 780,000 gal., of which about 530,000 gal. have been refined.

Queensland.—Near the town of Roma, deep drilling for water developed a natural gas well of sufficient size to supply the town until it suddenly clogged up, due probably to a cave. An officer of the Geological Survey was then delegated to submit all the geological evidence to various European and American experts and secure their opinions as to drilling for oil. Their final report was favorable and a competent drilling expert was sent to the United States for men and equipment for drilling to 4000 ft.

Oil wells were started in South Australia at Rohland and Kingston, guided by seepages.

Further exploration is in progress or planned in Papua on the north coast.

Africa

Egypt.—According to the *London Financial Times*, the weekly outputs published by the Anglo-Egyptian Oil Fields (Ltd.), have shown remarkable and, to some extent, unaccountable variation. Leaving out the phenomenal output in October last, when a new well produced 3000 tons in 24 hr. and had to be shut in pending storage and transport facilities, results showed round about 1700 tons a week during the last 3 months of 1914, and from the beginning of 1915 they have wandered in the strangest way between 195 and 880 tons weekly. On March 9, 1916 a cable was published stating that the new well was brought in again.

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Natural Gas

The only complete and accurate statement of production of the natural gas of the United States is that collected by the U. S. Geological Survey. In advance of that statement the amount produced in 1915 can only be estimated at a slight increase over the previous year; *i.e.*, 591,866,733 thousand cubic feet in 1914 valued at $94,115,524 and 600,000,000 thousand cubic feet in 1915 valued at $100,000,000—a gain also in the average price per thousand cubic feet.

While several exceptionally large gas wells were developed during the year, it is important and extremely encouraging to note that they were practically without significance in the statistical result. This means that the problem of keeping up the supply for an ever-increasing demand, and from natural gas areas where the pressure is always declining, was in the hands of careful exploiters who are concerned with protecting very great investments which would be worthless should the gas fail. In fact, it is the practical gas producer, rather than the professional conservationist, who has brought about practically all the reforms in saving in gas waste. In this the producer has been efficiently guided by the National Bureau of Mines. This bureau owes its success in gas conservation to its practice of recognizing skilled practical men on its staff. The coöperation of the Indian office has also been helpful. The most productive gas saver has been the separation of gas and oil in Oklahoma by the aid of mud-laden fluid as worked out by Pollard and Heggem, under the direction of W. A. Williams. Another important step was the development of the Stark gas and oil separator in California, which has inspired the invention of a host of other devices.

Even the increased production of gasoline from natural gas has helped the total supply of gas, for this comes from casing-head gas, most of which would otherwise not be saved at all.

The Appalachian Region.—The sensation of the year in Pennsylvania was a short-lived gas well of enormous pressure drilled late in the year on the Spiegel farm near East McKeesport, Allegheny County. The gas came from the "thirty-foot" sand, and went wild for several days. When first brought under control it showed over 50,000,000 cu. ft. a day, but rapidly declined and became exhausted in a month. The resulting drilling excitement was a great loss to the investors.

In October a gas well was drilled in Scott County, Tennessee, near Oneida, yielding 2,000,000 ft. a day. Drilling for gas was very active in central and northern Ohio, in the effort to keep up the supply. Over 700 gas wells were obtained and work was especially active in the Cuyahoga County field near Cleveland. Following an oil excitement near Saybrook in Ashtabula County enough gas was obtained to encourage drilling.

Indiana—Illinois.—Indiana was featureless as to gas, but in Illinois the Staunton field, in Macoupin County, yielded six fine gas wells.

Mid-continent Field.—Every recent oil strike has yielded also much gas, most of which has been promptly saved and sent into the pipes of the large gas companies. But there was also one interesting gas strike in the Eldorado and Augusta fields of Kansas. Some of this gas was peculiarly rich in nitrogen, even to the extent of the shallow gas being valueless.

In Arkansas one large gas well was drilled and utilized.

The Crichton and neighboring pools in northern Louisiana developed many large gas wells which were promptly piped to the Arkansas Natural Gas Co.

Texas.—The year 1915 was eventful for natural gas in Texas. The Border Natural Gas Co. brought in a well in Zapata County near the Rio Grande and only about 50 miles from Laredo. The flow was so strong—possibly 30,000,000 cu. ft. per day—that plans are complete for piping it 18 miles to Reiser to connect with the line to Laredo, and possibly

150 miles to Monterey, Mexico. Another large gas well was developed at White Point, near Corpus Christi, to which the Guffey Petroleum Co. proposes to pipe it. Many other gas fields are now receiving attention in Texas for power purposes. A significant piece of city work was undertaken by the U. S. Geological Survey and the Bureau of Mines at the request of the mayor of Dallas. It was developed that 40 per cent. of the Petrolia field is exhausted, leaving 70 billion cubic feet still available. The Mexia field still has 31 billion feet.

Wyoming and Montana.—The great gas well at Byron, in northwestern Wyoming, was brought under control and is about to be used to some extent as fuel for a sugar factory.

In the Salt Creek field the conservation of the natural gas accompanying the oil has become a model for the country. Not only is it used without waste for lighting, heating and for all power purposes, but the installation of a gasoline plant and eventually piping to Casper are under careful consideration.

In Havre, Mont., the natural gas well is still productive. The structural conditions are good for a considerable supply.

Canada

According to the Canadian Bureau of Mines, complete returns have not yet been received from some of the largest operators in Ontario. The 1915 production of natural gas therefore (subject to corrections of the estimates used) was approximately 18,319,710 thousand cubic feet valued at $3,300,825 contributed by provinces as follows: Ontario, 13,510,071 thousand cubic feet valued at $2,202,523; New Brunswick 430,692 thousand cubic feet valued at $60,383, and Alberta 4,378,947 thousand cubic feet valued at $1,037,919.

The production for the previous year was reported as 21,692,504 thousand cubic feet, valued at $3,484,727 of which amount Ontario produced 14,094,521 thousand cubic feet valued at $2,215,808; New Brunswick 425,826 thousand cubic feet valued at $54,249, and Alberta 7,172,157 thousand cubic feet valued at $1,214,670.

Ontario's production in 1915 showed a decrease of 584,450 thousand cubic feet, Alberta production a decrease of 2,793,210 thousand cubic feet, and New Brunswick production an increase of 4866 thousand cubic feet.

The Ontario gas production came from the same fields in the southern portion of the province between Niagara Falls and Windsor, as heretofore. In 1914 and 1915 gas from the Kent fields was distributed as far east as Hamilton, a distance of 153 miles.

The New Brunswick production is obtained in Albert County and supplies chiefly Hillsborough and Moncton, while in Alberta, Medicine Hat and Bow Island are still the principal gas fields being utilized, supplying the district between Medicine Hat and Calgary.

Gasoline from Natural Gas

The production of gasoline from natural gas showed more than the usual progress during 1915, the total exceeding 1,400,000 bbl. The increase was especially marked in the mid-continent field.

Experimental work by the Ohio Natural Gas Co., in coöperation with the Bureau of Mines and the Ohio State Geological Survey's chemical department, did much to advance the process of extracting gasoline by absorption in light lubricating oils from gas too poor for profitable handling by the compression processes.

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PHOSPHATE ROCK

By Wm. H. Waggaman

While many industries in this country have been stimulated, temporarily at least, on account of the abnormal conditions brought on by the great European conflict, the phosphate industry has been greatly curtailed in the United States and much more seriously affected abroad. Owing to disturbed conditions, accurate statistics concerning the production, consumption, exports and imports of phosphate bearing materials have been difficult and in some instances impossible to obtain, but the output of practically every fertilizer material has either been much curtailed or is being consumed in the manufacture of munitions rather than for agricultural purposes.

The world's production of phosphate rock in 1913 before the European struggle began was over 6,780,000 tons. In 1914 (the first year of the war) the production was a little less than 4,000,000 tons and in 1915 the output as far as can be learned at present was 3,573,301 tons. Of this amount the United States produced 1,873,625 tons and consumed 1,620,076 tons.

Up to the past year (1915) practically all of the phosphate rock marketed was treated with sulphuric acid (an equal weight approximately) and manufactured into acid phosphate for the fertilizer trade. Owing to the increased demand for sulphuric acid in the manufacture of munitions the price of acid phosphate has advanced considerably, so the farmer has sought other sources of phosphoric acid for fertilizer purposes. A somewhat greater consumption of raw ground rock phosphate has resulted and several concerns in Florida which had heretofore sold their rock for acid treatment only are advertising also the finely ground raw material for direct application to the field. In 1915 the amount of phosphate thus consumed (so far reported) amounted to 51,101 tons as against 50,750 tons in 1914.

While many methods have been devised for rendering the phosphoric acid of phosphate rock water-soluble or available by means other than the treatment with sulphuric acid, the quantity of phosphate rock thus consumed is as yet nearly negligible.

Taking up the phosphate deposits in the order of their present commercial importance they are as follows: The phosphates of the United

States, including those of great value and extent in Florida, Tennessee, South Carolina, and the Western States, Utah, Idaho, Wyoming and Montana, and deposits of lesser importance in Kentucky, Arkansas, North Carolina and Virginia; the deposits in northern Africa in Tunis, Algeria, and Egypt; the deposits of the Pacific and Indian Oceans, including those of Ocean, Christmas and Pleasant Islands and the islands of the Marshall and Society Groups; the phosphates of Russia; the phosphates of Belgium and France; the Peruvian guano deposits, and the many smaller deposits in various other countries.

The world's production of phosphates in is given in Table I.

TABLE I.—PRODUCTION OF PHOSPHATE IN THE WORLD
(In metric tons)

	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Algeria.........	452,060	351,491	(*d*)319,069	332,897	388,515	461,030	(*e*)355,140	*e*)225,891
Augaur Palan Iseln.	....	9,000	45,000	41,000	50,000	90,000	(*e*)60,000	
Belgium........	198,030	205,260	202,880	196,780	203,110	(*e*)178,455	(*e*)10,988	....
Canada.........	1,622	998	1,341	506	....	349	....	....
Christmas Island (*d*).	260,000	197,982	310,625	250,000	300,000	(*f*)150,005	....	....
Dutch W. Indies								
Aruba........	20,061	27,227	27,838	88,430	17,215	....	(*e*)86,572	....
Curacao......	....	....	3,570	2,000	....	1,850	(*e*)11,219	(*e*)32,915
Egypt..........	700	1,000	2,397	6,425	69,958	101,311	....	(*e*)1,796
France.........	485,607	397,903	333,506	312,204	330,000	335,000	....	....
French Guiana..	9,092	8,997	6,816	....	....	....	....	....
Makatea (*d*)....	....	....	....	12,000	40,000	82,000	....	....
Norway........	1,771	1,364	903	....	....	....	....	....
Ocean Island....	301,160	197,922	310,625	250,000	300,000	250,000	....	....
Russia..........	14,786	12,906	15,293	10,200	25,000	25,000	....	....
Spain..........	4,483	1,387	(*d*)2,840	3,520	3,292	3,548	....	....
Sweden.........	(*c*)	(*c*)	....	....	3,292	....	....	....
Tunis..........	1,300,500	1,223,512	1,286,262	(*a*)1,446,633	2,057,498	2,284,678	1,427,161	1,389,074
United States...	2,413,032	2,503,186	2,724,849	3,260,626	3,216,046	3,068,604	2,752,971	1,873,625
Japan..........	740	3,781	1,042	2,271	7,849	19,047	(*h*)50,000	(*h*)50,000

(*c*) Statistics not available.
(*d*) Figures furnished by Charles Michel, Paris.
(*e*) Exports.
(*f*) *American Fertilizer.*
(*g*) Exportation for first 6 months, 1914.
(*h*) Provisional figures.

United States

Since the amorphous phosphates of South Carolina were first exploited in 1868, the United States has been the foremost phosphate-producing nation in the world.

The famous Florida fields, the high-grade phosphates of Tennessee, and finally the vast deposits of phosphate in the western States gives this country a known reserve supply greater than that of any other nation.

The following data (Table II) were collected with great care in 1913 and while the figures must be considered approximate they may also be regarded as conservative. Rock grading from 58 to 70 per cent. tricalcium phosphate is classed as high-grade, and in the case of the low-grade phosphates in the West and the wash heaps of Florida, the material is figured to its equivalent in high-grade rock.

Even assuming that there are no new discoveries in the United States and that the average consumption during the life of the phosphate fields will be three times its present consumption, there is sufficient to last over 1100 years, provided proper mining methods are employed, and means for utilizing the lower-grade material are devised.

While several million tons of rock have been mined since these figures were compiled, new discoveries of phosphate have been made which more than offset the quantity of rock consumed.

TABLE II.—RESERVE SUPPLY OF PHOSPHATE ROCK IN UNITED STATES

	Tons.
Utah, Idaho, Wyoming and Montana:	
High grade	2,500,000,000
High-grade equivalent of all grades	7,500,000,000,
Florida:	
High-grade equivalent of all grades	354,300,000
High-grade equivalent of wash heaps	20,000,000
Tennessee:	
High-grade equivalent of all grades	115,075,000
S. Carolina:	
High-grade equivalent of all grades	10,000,000
Arkansas:	
High-grade equivalent of all grades	20,000,000
Kentucky:	
High-grade equivalent of all grades	500,000
	10,519,875,000

The production, consumption, and exports of phosphate rock in the United States for the past 4 years are given in the following tables:

TABLE III.—PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES

(In tons of 2240 lb.)

Phosphate.	1912.		1913.		1914.		1915.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Florida hard rock	536,379	$3,218,274	510,811	$3,371,386	(a)309,689	$1,912,197	42,962	$231,995
Florida land pebble	2,043,486	7,101,186	2,043,403	6,334,549	1,829,202	5,442,547	1,368,282	4,186,943
Florida river pebble	....	....	....	....	....	....	....	....
Total, Florida	2,579,865	$10,319,460	2,554,214	$9,705,935	2,138,891	$7,354,744	1,411,244	$4,418,938
S. Car. land rock	(a) 131,490	$524,760	109,333	$440,588	156,363	$496,907	78,543	$329,902
S. Car. river rock	....	....	....	....	....	....	....	....
Total, S. Carolina	131,490	$524,760	109,333	$440,588	156,363	$496,907	78,548	$329,902
Tennessee	443,065	$1,710,000	439,822	$1,649,303	451,942	$1,694,782	383,833	$1,343,416
Other States	(a) 11,612	46,450	5,050	18,167	5,775	17,323	....	....
Total, U. S.	3,166,032	$12,600,670	3,108,419	$11,813,993	2,752,971	$9,643,756	1,873,625	$6,092,256

(*a*) Reported by the U. S. Geol. Survey. (*c*) Idaho, Utah and Wyoming.

TABLE IV.—STATISTICS OF PHOSPHATES IN THE UNITED STATES (a)
(In tons of 2240 lb.)

Year.	Production.	Imports.	Exports. (b)	Consumption.
1906	2,052,742	46,228	904,214	1,194,756
1907	2,251,459	25,896	1,018,212	1,259,143
1908	2,375,031	26,734	1,196,175	1,205,590
1909	2,463,766	11,903	1,020,556	1,455,113
1910	2,681,938	19,319	1,083,037	1,618,220
1911	3,216,993	16,153	1,246,577	980,569
1912	3,166,032	28,821	1,206,520	1,988,333
1913	3,062,975	26,408	1,338,450	1,724,525
1914	2,752,971	15,078	928,992	1,839,057
1915	1,873,625	5,359	253,549	1,625,435

(a) Production statistics of 1901 and subsequent years, except 1905–1913, are those of the U. S. Geological Survey and are based on marketed products. (b) Neglecting the insignificant exports of foreign products.

The imports and exports of fertilizers of all kinds into the United States were as Tables V and VI:

TABLE V.—IMPORTS OF FERTILIZERS INTO THE UNITED STATES
(In tons of 2240 lb.)

	1911.		1912.		1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Ammon. sulphate	......	....	......	....	......	....	74,121	4,475,603	32,447	1,934,625
Phosphates (crude)	18,980	$203,326	20,685	$179,605	23,478	$184,204	15,078	136,526	5,359	50,606
Apatite	......	....	80	1,140	2,930	22,515	20	300	*nil*	....
Basic slag	13,150	89,175	11,751	110,229	15,124	145,477	74,588	1,501,542	76	1,343
Blood char (lb.)	661	347	......	....	2,954	333	(b)	....	(b)	....
Blood (dried)	......	448,739	......	220,297	......	86,065	(b)	....	(b)	....
Blood (dried) when soluble), lb.	4,897	280	7,701	423	6,412	339	(b)	....	(b	....
Bone char	......	22,448	......	20,414	......	12,484	(b)	....	(b)	....
Bone dust	44,635	1,134,443	118,535	913,023	33,919	818,306	36,022	890,672	21,322	540,197
Guano	31,740	625,044	34,856	685,140	16,461	313,898	25,562	762,688	9,974	220,860
Kainit	586,474	2,637,105	479,417	2,400,590	466,184	2,349,689	329,611	1,550,879	6,674	95,440
Keiserite	2,100	3,564	7,545	17,689	10,800	44,770	(b)	....	(b)	....
Cyanite	400	1,994	900	7,535	612	7,949	(b)	....	(b)	....
Manure salts	160,105	1,265,867	185,682	1 824,426	172,557	1,798,973	168,426	1,842,649	13,947	207,674
Potash (muriate)	214,284	6,449,575	242,033	7 235,729	223,836	6,737,757	168,509	5,740,893	57,774	2,297,149
Potash (sulphate)	53,139	1,952,370	50,551	1,853,236	48,022	1,798,369	36,246	1,568,704	11,344	663,399
Nitrate of soda	546,394	17,101,155	481,786	15,427,904	586,315	20,713,375	543,715	15,228,671	772,190	22,959,997
All other fertilizers	191,975	3,914,508	169,283	3,527,646	115,257	2,190,816	......	3,553,793	......	2,922,914

Florida.—The phosphates of Florida still hold first place among the most important deposits known to the world, located in one of the southern States where fully 80 per cent. of the fertilizer manufactured in this country is consumed, and having excellent transportation facilities both by rail and water, they are well fitted to supply our domestic needs. Moreover, their richness and even grade will no doubt continue to afford them a market in European countries for many years to come.

In the early part of 1914, 23 companies were actively engaged in mining operations but on the breaking out of the European war a gradual curtailment of production ensued resulting finally in the closing down of many plants altogether. At the close of 1914 only 19 out of 54 plants were in operation. In 1915 only 15 companies were operating in the Florida fields and most of these only intermittently. The total production for this year based on material marketed was 1,411,244 tons against 2,138,891 tons in 1914.

Since practically all of their product has heretofore been shipped abroad, the operators in the hard-rock field suffered more by the European war than those in the pebble regions of Florida or in Tennessee. In 1915 the marketed output of hard rock was 42,962 tons as against 309,689 tons in 1914 and 510,811 tons in 1913. 8,390 tons or about one-fifth of the total amount was consumed in this country. The average price of the hard-rock phosphate f.o.b. ports was about $5.40 per ton.

Since the outbreak of the war freight rates on phosphate rock to European ports have risen enormously, making it practically impossible to profitably ship a material which is chiefly used in the production of fertilizers.

TABLE VI.—EXPORTS OF FERTILIZER MATERIALS IN 1914 AND 1915

	1914.		1915.	
	Quantity.	Value.	Quantity.	Value.
Sulphur or brimstone, crude, tons	98,153	1,807,334	37,312	724,679
Phosphate rock, not acidulated:				
High-grade hard rock, tons	281,806	2,818,060	34,572	331,524
Land pebble, tons	681,241	3,948,079	218,620	1,269,789
All other, tons	1,067	5,513	357	4,326
All other fertilizers, tons	63,554	1,311,227	114,215	2,782,346
Exported to—				
Belgium	91,797	591,308	....	....
France	108,760	653,637	4,732	274,950
Germany	219,732	1,886,437	745	7,450
Italy	83,824	506,776	7,964	45,984
Netherlands	115,760	894,101	50,733	339,430
United Kingdom	138,899	827,502	79,044	443,210
Other Europe	149,300	1,115,899	118,715	943,071
Canada	40,479	752,357	40,987	822,944
West Indies and Bermuda	23,956	457,571	59,144	1,327,070
Japan	48,055	287,988	27	1,281
Other countries	7,106	109,233	5,633	182,595
Cottonseed meal, lb	999,467,765	13,033,872	165,710,192	2,296,349

In 1915 only 3 companies actually mined any rock; several others made a few shipments of stock carried over from 1914.

The European conflict has caused a serioucs urtailment in the production of pebble phosphate. The output from these fields has heretofore been about equally divided between the foreign and domestic markets. High freight rates, lack of steamers, and the difficulty of entering certain foreign ports have cut down the export trade to a minimum.

The pebble phosphate on the whole is of lower grade than the hard rock, averaging about 70 per cent. bone phosphate of lime. Several concerns, however, with exceptionally rich deposits have been guaranteeing their product to run as high as 75 to 77 per cent. In the early part of 1914, 13 companies were engaged in mining or shipping pebble phosphate, but many of these were closed down entirely at the end of the year and others were running only intermittently. In 1915, 12 companies were engaged in mining operations but some of these were only runrunning their plants intermittently. The marketed output in 1915 amounted to 1,368,282 tons. Of this amount 218,620 tons were exported and 1,149,662 tons consumed in this country. The average price for the year f.o.b. ports was $3.06 per ton.

The production of Florida phosphates for the past 5 years is given in Table VII.

TABLE VII.—STATISTICS OF FLORIDA PHOSPHATE
(In long tons)

Year.	Production.			Total Shipments.	Domestic Consignment.	Exports.
	Hard Rock.	Pebble.	Total.			
1911	474,094	2,020,477	2,494,571	2,456,440	1,290,779	1,165,661
1912	536,379	2,043,486	2,579,865	2,422,932	1,219,927	1,203,005
1913	510,811	2,043,403	2,554,214	2,554,214	1,130,764	1,363,450
1914	309,689	1,787,597	2,138,891	2,138,891	1,209,898	928,993
1915	42,962	1,368,282	1,411,244	1,411,244	1,158,052	253,192

Tennessee.—The two classes of rock which are of main commercial importance in Tennessee are the blue and the brown phosphates occurring in Maury, Hickman, Lewis and Giles Counties. The deposits of white phosphate in Perry and Decatur Counties, while containing some very high-grade material, are so irregular in character and so much less accessible than the other types that they have been developed to a very limited extent.

The brown rock is still being the most actively exploited since the material is on the whole of a higher grade and more readily workable. These deposits are very well situated for the distribution of rock to the fertilizer centers of the South and Middle West but not as favorably located for the export trade.

In 1915, ten companies were engaged in mining Tennessee phosphate. Their total marketed output amounted to 383,833 tons as against 451,942 tons in 1914. All but 93 tons of this output was consumed in the United States. The average price of the rock f.o.b. mines was $3.50 per long ton.

In January, 1915, an entirely new field of phosphate was discovered[1] near Mountain City, Johnson County, Tenn. An examination of this region made later in the year by Jenkins[2] of the state Geological Survey showed that the average phosphoric acid content of the rock thus

[1] Maxwell, H. V., *Eng. Min. Jour.*, June 26, 1916; Watkins, J. H., *Min. Eng. World*, Aug. 7, 1915, p. 217.

[2] Phosphates and Dolomites of Johnson Co., Tenn. *Resources of Tenn.*, **6**, No. 2, p. 5–106, April, 1916.

far uncovered is too low to make the material of commercial value except for local use.

South Carolina.—The production of phosphate in South Carolina in 1915 amounted to 78,548 tons as against 156,363 tons in 1914. This decrease in production of nearly 50 per cent. was due in part no doubt to the fact that less Florida rock was exported and competition for the domestic trade was consequently keener. The average grade of the South Carolina rock is 60 per cent. bone phosphate of lime and its average price f.o.b. ports during 1915 was $4.21 per ton.

It is obvious, therefore, that the rock is unable to compete with the higher-grade product from other sources, except for local consumption. Much of the rock is shipped to Charleston and made into double acid phosphate, a concentrated fertilizer.

South Carolina phosphate is mined by first removing the overburden with steam shovels, then digging out the phosphate stratum thus exposed. The material is then loaded on flat cars, carried to the washer and washed, screened and dried.

Utah, Idaho, Wyoming and Montana.—The phosphate deposits in these states are the most extensive ever discovered. The rock is of Carboniferous age and occurs as a bedded deposit having an oolitic structure and varies in color from light gray to jet black. The various beds range in thickness from a few inches to 6 ft. or more, with an average grade of about 70 per cent. bone phosphate of lime.

A great deal of phosphate occurs on government land and in order to conserve these deposits for domestic use large areas in the above States have been withdrawn from entry. Provision has been made, however, for the leasing of such lands on the payment of royalty to the government. The withdrawals outstanding June 30, 1915, according to the figures of the U. S. Geological Survey were 2,660,336 acres in Florida, Idaho, Utah, Wyoming and Montana.

Claims had already been filed on much valuable land before any withdrawals were made so several companies own, or control, very rich deposits of phosphate in Utah, Idaho and Wyoming, but up to the present time the limited use of fertilizer in the West and the heavy cost of hauling the material to a more ready market have prevented the development of these fields.

The fast growing necessity of preventing the escape of sulphur fumes from the smelters in Montana and Utah, however, may force the copper producers to manufacture fertilizer material. By producing concentrated phosphoric acid or double acid phosphate they may be able to compete with the Eastern phosphates.

The discovery of phosphate on both the north and south sides of the

Uinta Mountains led to the withdrawal of 224,558 acres additional in 1915 pending a further investigation. This discovery coupled with the estimate of Stone and Bonne[1] of 860,000,000 tons of rock in the Elliston Field, Montana and Mansfield's[2] discovery of further beds of phosphate in the Salt River Range, Wyoming, should add considerably to the tonnage of western phosphate.

In the latter part of February, 1915, the Montana Phosphate Co. was organized with a capital stock of $2,000,000. The company has secured leases on 200 acres of land in the vicinity of Philipsburg and Maxwell and planned to erect a plant at the latter place.

Three other companies have actually mined and shipped rock from the western phosphate fields but no production has been reported during 1915.

Arkansas.—No production has been reported from Arkansas since 1912. The mines near Batesville have been shut down, as it has been found more practicable to supply the demand for phosphate just west of the Mississippi from the higher-grade deposits of Tennessee.

Kentucky.—Several small deposits of high-grade phosphate rock have been found in the Ordovician limestone in Woodford, Scott, Fayette and Jessamine Counties. The Kentucky phosphate occurs in thin close-grained plates, brownish gray in color and resembling closely the brown rock phosphate of Tennessee. Much of the rock will run 75 per cent. bone phosphate of lime.

The "Central Kentucky Phosphate Co.," the only concern operating in the Kentucky field sold out its plant near Midway in the summer of 1914 to the Charleston Mining and Manufacturing Co. Preparations were under way in 1915 to re-open this plant under the name of the "United Phosphate and Chemical Co." In the latter part of the summer of 1915 a farm of 275 acres near Midway, estimated to be underlain by 500,000 tons of phosphate rock was reported sold for mining purposes.

A few thousand tons of phosphate were marketed from the Kentucky fields in 1914, but no production has been reported for 1915.

Phosphates in Foreign Countries

Africa

The phosphates of northern Africa, including those of Tunis, Algeria, and Egypt are next in importance to those of the United States. Whereas the material on the whole is not as high-grade as that from Florida and

[1] Elliston Phosphate Field, Montana, *Bull.* 580-N, U. S. Geol. Surv., 1914.
[2] A Geol. Reconnaissance for phosphate in the Salt River Range of Wyoming, *Bull.* 620-0, U. S. Geol. Surv. (1915).

Tennessee, its nearness to the European market has made it in recent years a serious competitor of the American product for the export trade.

Since the outbreak of the war, however, the production from all African deposits has fallen off considerably, due to a more limited market for the material.

In 1915 the total output from the three fields in northern Africa amounted to 1,647,880 tons as against 1,868,873 tons in 1914. These figures do not represent the production for the above years since part of the material exported was probably mined the year previous.

Tunis.—Tunis has an annual output of phosphate rock second only to that of Florida. In 1915 in spite of the unfavorable conditions existing on account of the war 1,389,074 tons were produced of which 1,100,000 tons were exported. In 1914 the exportations of Tunisian phosphate amounted to 1,427,161 tons. It will be seen that while Germany has heretofore been a large consumer of the phosphates from Algeria and Tunis the cutting off of that market has not decreased the production of rock as greatly as one would expect.

The main phosphate district is in the vicinity of Gafsa, which is connected with the port of Sfax by a railroad 150 miles long. The phosphate occurs as gigantic lenses of condiserable thickness and ranges in grade from 58 to 68 per cent. bone phosphate of lime. The mining is done by open cuts as well as by tunnels.

The "Societe des Phosphates de Gafsa," which controls all the phosphate properties in the Gafsa region, is the largest single producer of phosphate in the world, and up to 1914 has continually increased its annual output. The other companies in Tunis are the "Societes des Phosphates Tunisiens," and the "Compagnie des Phosphates du Dyr."

The average price of Tunisian phosphate in 1914 up to the time of the war was about 10.2 cts. per unit $Ca_2(PO_4)_2$. In 1915 the average price of the phosphate c.i.f. Mediterranean was 12.5 cts. per unit of $Ca_3(PO_4)_2$.

TABLE VIII.—SHIPMENTS OF PHOSPHATE ROCK FROM ALGERIA AND TUNIS
(In metric tons)

Year.	Algeria.	Tunis.	Year.	Algeria.	Tunis.
1896	142,524	....	1906	302,262	747,303
1897	227,870	....	1907	343,085	956,998
1898	269,572	....	1908	362,890	1,270,020
1899	286,681	65,209	1909	351,491	1,224,822
1900	277,896	171,288	1910	319,069	1,286,262
1901	278,185	178,019	1911(*a*)	332,897	1,446,633
1902	265,964	266,553	1912(*a*)	388,515	1,923,000(*b*)
1903	301,112	360,621	1913	438,601	1,984,880
1904	344,969	457,133	1914	355,140	1,427,161
1905	347,747	529,645	1915	225,891	1,100,000

(*a*) Figures furnished by Charles Michel, Paris. (*b*) Estimate.

Algeria.—The phosphates of Algeria are of the same type as those of Tunis, but have not been developed to the same extent. The exportations in 1915 amounted to 225,891 tons as against 355,140 tons the previous year (1914).

The most important company mining in Algeria is the "Compagnie des Phosphates de Constantine." Its production in 1913 amounted to 314,168 tons. Other companies operating in these fields are the "Compagnie Centrale," the "Compagnie Algerienne des Phosphates de Tocqueville," and the "Compagnie de M'Zaita."

The average price of the Algerian phosphate during 1915 was the same as that of the Tunisian product.

Algeria has recently erected plants for the manufacture of acid phosphate and is now conducting quite an export trade in this material. The amount exported during 1915 was 22,122 tons.

The shipments of phosphate from Tunis and Algeria since 1896 are given in Table VIII.

Egypt.—Phosphate deposits have been found in various parts of the Egyptian desert regions and in the valley of the Nile. The rock is of Cretaceous age and varies in grade from 30 to 68 per cent. bone phosphate of lime.

Mining is being conducted in two localties; in the Safaga district near the Red Sea coast and in the Sibaria district on both sides of the Nile.

The production in 1915 based on the quantity exported was 32,915 tons as against 86,572 tons in 1914. Most of the Egyptian phosphate is shipped to Japan.

An examination of the Egyptian phosphate deposits by a representative of the Gafsa Co. showed that with the exception of the deposits in the Safaga district, the tonnage of rock available along the coast of the Red Sea was very limited.

Islands of the Pacific and Indian Oceans

The phosphate deposits which occur in several islands of the Pacific and Indian Oceans are of the highest grade yet discovered. Among the more important phosphate-producing islands of the Pacific are Ocean Island (English) of the Guilbert Group, Tahiti and Makatea (French) of the Society Group, and the Island of Naru (Japan) of the Marshall Group. Besides these, Christmas Island in the Indian Ocean contains a large tonnage of high-grade rock. The statistics showing the total production from these islands in 1913, 1914 and 1915 have not yet been published, but in 1912 the total exportations amounted to 600,000 tons. Christmas Island produced in 1913, 150,005 tons.

The German phosphate holdings in islands of the Pacific Ocean have been confiscated by England and Japan. The Marshall group alone is estimated to contain 50,000,000 tons of high-grade phosphate rock.

Phosphate rock has recently been discovered in New Zealand, the most important deposits recorded are at Milburn, Otayo and on Bounty and Antipodes Islands. A company has been formed with a capital of $1,250,000 to manufacture sulphuric acid and acid sulphate to meet, in part at least, the fertilizer demand of this island. The value of the imports of fertilizers into New Zealand in 1913 amounted to $1,836,724.

Europe

Russia.—There are three main regions in Russia containing phosphate rock of commercial value. Named in the order of their present importance they are as follows:

The Southern region, in the governments of Podolia and Bessaribia where the deposits are close to the Austrian frontier; the Northern region, where the deposits occur in Jurassic and Cretaceous rocks in the governments of Viatka Vladimir, Kostrom, Ryazan, Sunbir and Yaroslavl; and the Central region of Cretaceous phosphates which are found in the governments of Voronezh, Kaluzh, Kursz, Orel, Saratoff, Smolensk, Tamboff and Chernigoff.

The Northern and Southern regions have been examined geologically and the latter exploited, but little is known of the Central region except that phosphate exists in considerable quantities.

The phosphates of the Southern region are mined chiefly by underground workings. Some of the rock is said to contain as high as 75 per cent. bone phosphate and lime. The deposits so far examined are estimated to contain 1,612,903,000 tons of phosphate but much of this material will grade below 24 per cent. P_2O_5.

Since most of the fertilizer used in Russia has heretofore been imported, the situation is at present very grave and efforts are being made to install factories to meet the agricultural demands. The production of Russian phosphates for 1907–1913 is given in Table IX. Later statistics are not yet available. The average price delivered at the railway station was $9.30 per ton.

TABLE IX.—PRODUCTION OF PHOSPHATE ROCK IN RUSSIA
(Metric tons)

Year.	Amount.	Value.
1907	11,290	$104,997
1908	14,786	137,510
1909	12,906	120,226
1910	15,293	142,225
1911	10,200	94,860
1912	25,000	....
1913	25,000	....

Fertilizers have been imported to Russia in large quantities from Germany, Belgium and England.

TABLE X.—IMPORTS OF FERTILIZERS TO RUSSIA

	1912, Poods.	1913, Poods.	1914, Poods.	1915.
Mineral Phosphorites	....	3,800,000	1,239,512(*a*)	....
Other Nat. Fertilizers	....	5,000,000	....	....
Crude Ground Bones	....	154,089	16,900(*a*)	10,024
Ground Thomas Slag	11,258,471	11,366,463	7,105,427(*a*)	(*b*)199,260
Superphosphates	11,491,153	12,000,000	7,214,940(*a*)	7,471,819
Roasted Bones	....	....	....	....
Stassfurt Salts, German	....	4,700,000	....	15,050
Chloride of Potassium	....	....	....	....
Chile Saltpeter	....	1,000,000	3,233,008	(*b*)1,790,220

(*a*) Jan. to Oct., 1914. (*b*) First 11 months.

France and Belgium.—The phosphate deposits of France and Belgium at one time largely supplied the European demand for phosphatic fertilizers but the annual production from these sources just prior to the war had fallen off to such an extent that their output was but a small percentage of the world's total production. The great decrease in mining in these countries was due in part to the depletion of the deposits and part to the discovery of the higher-grade phosphates in other countries. The amount of phosphate rock exported by France in 1915 was approximately 1800 tons as against 11,219 tons in 1914. It is not known whether this material was from local deposits or represents rock from Africa re-shipped to other countries.

Both France and Belguim have been large importers of phosphate rock and the latter country up to the time of the war produced and exported annually a large tonnage of basic (phosphatic) slag a by-product of the steel industry. Since a large portion of Belgium is at present under German control no figures on production have been obtained for 1915. The imports and exports of these two countries as far as could be obtained are given in Tables XI and XII.

TABLE XI.—FRENCH IMPORTS AND EXPORTS OF PHOSPHATE ROCK
(In metric tons)

Year.	Imports.	Exports.
1912	903,489	22,062
1913	934,688	21,128
1914	(*a*)647,769	11,219
1915	(*b*)325,114	(*b*)1,796

(*a*) 10 months. (*b*) Providence figures.

TABLE XII.—BELGIAN IMPORTS AND EXPORTS OF PHOSPHATE ROCK
(In metric ton)

Year.	Imports.	Exports.
1912	244,221	22,916
1913	244,765	18,158
1914	(*a*)113,668	(*a*)10,988
1915	....	....

(*a*) First 6 months of 1914.

TABLE XIII.—BELGIAN IMPORTS AND EXPORTS OF BASIC SLAG
(In metric tons)

Year.	Imports.	Exports.
1912	130,439	550,841
1913	144,553	685,907
1914	(*a*)76,248	(*a*)335,016
1915	....	....

(*a*) First 6 months of 1914.

Germany.—With the exception of those contained on several insular possessions, which have now been confiscated by England and Japan, Germany has no phosphate deposits of commercial value, and has therefore depended largely on her imports from other countries to supply her phosphatic fertilizers. The present blockade of German ports is what has affected the phosphate industry in Florida and Tunis so seriously since heretofore a large percentage of the rock exported from these fields has been shipped to Germany. The demand for phosphatic manures in Germany, however, can be partly met by the large production of basic slag, a production which has no doubt been much increased because of the greater consumption of steel. Up to the present war much of the slag was shipped out of the country, but it is now conserved for domestic use.

The imports of phosphate to Germany for 1911–14 inclusive are given in Table XIV, and the imports and exports of slag in Table XV.

TABLE XIV.—IMPORTS OF PHOSPHATE INTO GERMANY
(Metric tons)

Imported from	1911.	1912.	1913.	1914.
United States	378,770.4	342,646.3	421,212	420,163(*a*)
Algeria	164,691.9	190,747.9	107,405	
Tunis	62,267.1	115,206.1	108,707	
Belgium	91,265.9	63,011.0	53,433	
Christmas Islands	63,778.6	52,015.9	70,467	
Australia	20,804.3	49,248.1	18,866	
German Australasia	17,005.3	44,257.7	....	
France	15,681.9	40,686.4	19,529	
Other countries	18,994.2	5,024.8	4,129	
Total	833,259.6	902,844.2	803,748	
Total value	$9,915,794.0	$10,743,796.0	$8,664,953	

(*a*) First 6 months of 1914.

TABLE XV.—GERMAN IMPORTS AND EXPORTS OF BASIC SLAG
(In metric tons)

Year.	Imports.	Exports.
1912	372,835	663,024
1913	441,069	713,878
1914	(*a*)234,081	(*a*)307,106

(*a*) First 6 months of 1914.

England.—Phosphate in the form of coprolites has been found in various parts of the British Isles, but not in sufficient quantities to prove of commercial importance.

This country, however, controls the rich deposits of phosphate on Ocean Island and has confiscated, since the war, several valuable phosphate deposits belonging to Germany.

England also has a large annual output of basic slag.

The imports and exports of fertilizer materials for the past 4 years are given in Tables XVI and XVII. The increased cost of shipping has had an appreciable effect on both the exports and imports of fertilizer materials.

TABLE XVI.—IMPORTATIONS OF PHOSPHATE MATERIALS TO ENGLAND
(Metric tons)

Material.	1912.	1913.	1914.	1915.
Basic slag	(*a*) 41,883	(*a*) 43,403	16,838	(*b*)
Guano	11,723	17,285	39,915	(*b*) 27,159
Phosphate rock	462,414	486,989	564,521	(*b*)380,651
Total	516,020	547,677	621,274	407,810

(*a*) First 11 months.

TABLE XVII.—EXPORTATIONS OF PHOSPHATIC MATERIALS FROM ENGLAND
(Metric tons, 11 months)

Material.	1912.	1913.	1914.	1915.
Superphosphate	(*a*) 82,514	(*a*) 61,416	67,111	(*b*) 69,838
Phosphate rock	4,492	11,808	2,646	....
Basic slag	(*a*)148,180	(*a*)157,207	134,808	(*b*)119,373
Total	235,186	230,431	203,565	189,210

(*a*) First 11 months. (*b*) Includes Ireland.

Spain.—The mining of phosphate rock in Spain has now practically ceased. In 1912, 3892 tons of low-grade phosphate was produced, but no production has since been reported. The imports of phosphate-bearing substances for the past 3 years are given in Table XVIII.

TABLE XVIII.—IMPORTS TO SPAIN (a)
(In metric tons)

Material.	1912.	1913.	1914.	1915.
Phosphate rock	176,183	254,463	(b)163,921	212,085
Basic slag	....	....	....	....
Superphosphate	161,047	149,602	(c) 116,897	(c)63,013
Guano	2,486	1,781	(b) 2,382	946

(a) Figures obtained from Le Movement Int. des Engrais Chimiques, No. 2, Rome, 1915. January to October. (c) Includes basic slag.

South America

Peru.—The deposits of guano owned and controlled by this country have been important sources of nitrogen and phosphoric acid since 1842. These deposits have furnished many millions of tons for agricultural purposes, but with proper precautions for their conservation they can continue to supply a large annual tonnage almost indefinitely.

In 1890 the Peruvian Corporation, Ltd., an English company, was granted the right to take guano from Peruvian territory up to the amount of 3,000,000 tons (an allowance which was afterward reduced to 2,000,000 tons) and over 50 per cent. from the Lobos Islands. Since that time, up to April, 1913, the corporation had exported 1,134,918 tons.

In the early part of 1915 the Peruvian Congress passed a law declaring a preferential right in favor of national agriculture, thus canceling the former agreements. The government has taken this stand because most of the guano is being shipped out of the country, to the serious detriment of the agricultural interests of the country. The Peruvian Corporation, Ltd., is making every effort to bring about a reversal of the law.

The local demand for Peruvian guano in recent years has been far greater than the amount supplied.

The consumption of guano in Peru (both high and low grades) for the past 5 years was as follows:

	Tons.		Tons.
1909–10	26,220	1912–13	36,592
1910–11	25,083	1913–14	38,787
1911–12	39,456		

TABLE XIX.—PRODUCTION AND EXPORTATIONS OF PERUVIAN GUANO
(In metric tons)

	1912.	1913.
Production	72,305	74,337
Exportations	38,633	37,530

The figures giving the total production and exports of Peruvian guano for 1914 and 1915 are not yet available; the amounts produced in 1912 and 1913, however, are given in Table XIX.

Argentina and Uraguay.—These two countries normally export considerable quantities of both guano and bones but the high freight rates and lack of carriers seriously curtailed these exportations during 1915. The exportations for the past 3 years are given in Table XX.

TABLE XX.—EXPORTS OF BONES AND GUANO FROM ARGENTINA AND URUGUAY

	1913.		1914.		1915.	
	Guano.	Bones.	Guano.	Bones.	Guano.	Bones.
Argentina	28,630	30,716	21,972	32,479	12,119	15,056
Uruguay	....	7,045	5,662	7,729	1,435	286

ASIA

Japan.—Most of the phosphate heretofore used in Japan has been imported from the United States, Egypt and the islands of the Pacific. Several years ago phosphate rock was discovered by the Japanese on Rasa Island at the extreme end of the Loochoo Group and a company formed for the exploitation of the deposits. It was estimated that the total tonnage on this island amounted to 2,800,000 tons. While it was first thought to be extremely high-grade rock later reports indicate that the material contains large amounts of iron and alumina making it difficult to manufacture acid phosphates therefrom.

Since the seizure of the Marshall Island (formerly a German possession) the Japanese have planned to exploit the high-grade phosphate deposits contained thereon and it is expected that this phosphate will soon be used in Japan in large quantities.

The production of phosphate rock in Japan (Rasa Island) amounted to about 50,000 tons in 1915 as against 28,022 tons in 1914. The imports of phosphate from various countries for the past 4 years are given in Table XXI.

TABLE XXI.—IMPORTS OF PHOSPHATE ROCK TO JAPAN

Country.	1911.	1912.	1913.	1914. (*a*)	1915.
England	5	....	21,990	(*b*)	135,800
France	5,450	....	....	....	
United States	81,900	74,700	38,740	54,063	
Egypt	....	10,220	29,700	68,157	
Other countries	141,000	198,000	238,150	144,702	

(*a*) From January to September, 1914. (*b*) Included in figures for other countries.

China.—No production of phosphate has been reported from China, but it has been stated that deposits of phosphate occur on the Pratas Islands, 170 miles south of Hong Kong. A Chinese company, the "Tony Sartou and Pratas Islands Phosphate Syndicate," has obtained concessions to work the deposits, which are estimated to contain 960,000 tons.

West Indies

Several islands in the Caribbean Sea (notably Curacao and Aruba) contain phosphate deposits of excellent quality. In October, 1913, mining was resumed on the Island of Curacao after a suspension of 20 years. A total of 1850 tons was produced from the island in 1913. No figures have yet been obtained for 1914 or 1915. An English company was mining the rock, which is of exceptionally high-grade, containing from 80 to 85 per cent. bone phosphate of lime and less than 1 per cent. of the combined oxides of iron and aluminum.

Technology

The question of utilizing lower-grade phosphates or recovering phosphoric acid therefrom divides itself into the study of two broad problems: (1) Mechanical means of treating the material with a view to raising the grade; (2) chemical methods of separating the phosphoric acid or rendering the phosphate soluble, by which it is possible to utilize rock valueless for acid phosphate manufacture.

Hoover and Mason's Device.[1]—These inventors have devised an apparatus which they state is very efficient in effecting a complete separation of the fine Tennessee phosphate from the impurities with which it is associated. It consists of a plurality of concentrically arranged superimposed annular members or holders provided with inwardly extending beater arms and internested together in overlapping relation. Each alternating member or holder is attached to a vertical shaft which slowly revolves when the apparatus is in operation. The phosphatic material is first crushed and then fed into the upper part of the apparatus and treated with sufficient water to form a thick mortar-like mass. The constant attrition to which the material is submitted in working its way down from one chamber to the next disengages the clay adhering to the phosphate and admits of its separation by subsequent treatment with larger quantities of water.

Process of Cowles.[2]—This is a process for rendering available the phosphoric acid of phosphate rock and the potash of feldspar and consists in heating a mixture of the two substances together to the sintering temperature. The resulting mass may be ground and used directly as a fertilizer or treated with sulphuric acid and the potash and phosphoric acid thus dissolved and subsequently separated from the solution.

[1] U. S. Patent No. 1124442 (1915).
[2] U. S. Patent No. 1126408 (1915).

Willson and Haff's Process.[1]—This is a process for making a complete fertilizer and consists in adding phosphoric acid and potash to phosphate rock to produce double superphosphate containing potash. Ammonia gas is then run into the mixture until the acidity is neutralized. It is said that a dry pulverulent high-grade fertilizer results.

Newberry and Barrett's Process.[2]—In order to convert the phosphoric acid of phosphate rock into an available or citrate soluble form without the use of acid, Newberry and Barrett have devised the following scheme. The phosphate is ground and mixed with an alkali metal compound and the whole made into a paste with water. The mix is then heated so as to drive off the water. A porous mass is thus obtained which is subjected to a higher temperature (2000° F.) in a rotary kiln and subjected to the action of a rapid current of gas. Under these conditions it is said that the volatile portion of the alkali metal compound is evolved and the phosphate left in a citrate soluble form. Emphasis is placed on the importance of having the material in a porous condition in order that the gases of combustion may have their full effect.

Stoltzenberg's Process and Product.[3]—The object of this process is to utilize "Vinasse" a waste product obtained in the manufacture of wine, but which contains considerable fertilizer material. Owing to the hygroscopic nature of "Vinasse" it has heretofore been impractical to spread it on the fields, so it is proposed to mix it with superphosphate and heat the mass to a temperature somewhat above 100° C. A reaction then takes place and much of the water contained in the "Vinasse" is driven off. The residue it is said consists of a dry non-hygroscopic mass of considerable fertilizer value.

Washburn's Process.[4]—This inventor proposes to mix ammonium phosphate with ignited alunite in order to obtain a high-grade fertilizer containing phosphoric acid, nitrogen and potash in readily available forms. Ignited alunite contains from 12 to 16 per cent. of potash depending on the purity of the mineral.

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[1] U. S. Patent No. 1145107 (1915).
[2] U. S. Patent No. 1162802 (1915).
[3] U. S. Patent No. 1104326 (1915).
[4] U. S. Patents 165845 and 165846 (1915).

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PLATINUM

At the beginning of 1915 the platinum market at New York was quiet at $41 @ 42 per oz. for refined. During the first quarter there was but little change, though prices were easier if anything, some business being reported as low as $38. On the other hand, there was improvement in the market for crude platinum at Ekaterinburg. The Russian government stopped the export of platinum. At a conference of gold and platinum producers in Petrograd it was reported that the smaller producers had ceased working. The stock of platinum was large, but generally it was in strong hands. In April the Russian government permitted resumption of exports, but imposed special conditions. However, there was no difficulty in securing permits for exportation to friendly countries. About May 1 it was reported that 46,000 oz. of crude platinum was held by the banks in Petrograd and Ekaterinburg.

At the mid-year the price for refined platinum at New York was $37 @ 39 per oz. About the middle of August an upward tendency began to be exhibited, the first change in the quotation being to $39½ @ 41. It was not, however, until the first week of September that consumers awoke to a realization that the market was short of supplies. In that week the price rose from $42 to $48 @ 50. This was about the season when manufacturing jewelers are accustomed to buy largely. During the remainder of September the market was uneasy. This situation continued into November, when the quotation at New York was $52 @ 56 per oz. In the meanwhile there had been a crazy market in Russia, where platinum had been bought largely for export, wherefor it was as good a medium of exchange as gold, while there was an increased domestic demand from sulphuric-acid concentrators, who were expanding their plants.

During November the price for platinum at New York rose rapidly. By the end of the month the quotation was $70 @ 74 per oz. In Russia there was a similar advance, and from there it was reported that abandoned mines in the Urals were being re-opened. During December the market was very excited, and at the end of the month the quotation was about $90 per oz. Refiners were disinclined to quote except to their regular customers, and supplies in Russia were being held back, their holders expecting still higher prices.[1]

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

AVERAGE PRICES OF PLATINUM
(In dollars per ounce troy)

	1914.			1915.		
	New York Refined Platinum.	Russia, 83 Per Cent. St. Petersburg.	Crude Metal Platinum Ekaterinburg.	New York Refined Platinum.	Russia, 83 Per Cent. St. Petersburg.	Crude Metal Platinum Ekaterinburg.
January	43.38	36.43	36.28	41.10	....	....
February	43.50	36.36	36.28	40.00	30.38	30.08
March	43.50	36.39	36.28	39.50	30.38	30.08
April	43.50	36.46	36.28	38.63	30.38	30.08
May	43.50	36.41	36.28	38.50	30.57	30.08
June	43.50	36.09	36.00	38.00	32.39	31.02
July	43.50	35.72	35.72	38.00	32.39	31.02
August	50.20	....	....	39.25	32.30	30.73
September	50.00	....	35.72	50.00	....	....
October	49.50	....	33.84	54.50	37.98	38.70
November	45.45	....	....	62.63	47.46	46.64
December	42.19	....	....	85.50	56.40	56.25
Year	45.14	....	....	47.13	....	....

New York average for year 1913, $44.88; 1912, $45.55; 1911, $43.12; 1910, $32.70 per oz. Troy.

According to the statistics of the U. S. Geological Survey, the production of refined platinum in the United States in 1914 was 3430 oz., or more than three times that reported in 1913, when it was 1034 oz. The production in 1914 included 570 oz. crude platinum from placer mining in Oregon and California, equal to 525 oz. refined metal; this was an increase of 141 oz. over the previous year. Of the crude metal 108 oz. came from Oregon and 462 oz. from the dredge operations of Butte, Yuba, Sacramento and Calaveras Counties in California.

The second source of platinum in 1914 was the Boss gold mine near Goodsprings, Nev., where platinum was first recovered and saved in 1913. In 1914 this mine produced 110 oz., which was parted from the gold.

AVERAGE MONTHLY PRICES OF PLATINUM AT NEW YORK
(In dollars per troy ounce)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.
January	20.50	38.00	25.50	24.10	29.00	39.06	46.00	45.50	43.38
February	25.00	38.00	25.50	24.00	28.75	39.31	45.63	45.50	43.50
March	25.00	37.00	25.50	23.75	29.13	41.00	45.50	45.50	43.50
April	25.00	32.50	23.50	23.50	29.25	41.35	45.50	45.50	43.50
May	25.00	29.50	22.50	23.25	29.55	42.81	45.50	45.50	43.50
June	25.40	26.20	23.50	22.75	31.38	42.88	45.50	45.50	43.50
July	26.00	26.75	20.00	22.43	33.00	42.95	45.50	45.50	43.50
August	26.00	28.13	18.75	22.65	33.00	44.38	45.50	44.90	50.20
September	32.10	28.70	20.00	25.31	33.63	45.31	45.50	43.96	50.00
October	33.00	27.13	21.50	27.75	37.50	46.25	45.50	44.00	49.50
November	35.50	26.31	24.00	29.50	39.44	46.13	45.50	43.70	45.45
December	38.00	26.00	24.00	29.50	38.75	46.00	45.50	43.45	42.19
Year	28.04	28.18	22.85	24.87	32.70	43.12	45.55	44.88	45.14

The discovery of platinum-bearing gold ore at the Boss mine was announced in October, 1914. The mine is situated in the Yellow Pine mining district, Clark County, near the extreme southern part of Nevada.

The main settlement of the district is Good Springs, distant 8 miles from Jean, a station on the San Pedro, Los Angeles & Salt Lake railroad. Good Springs lies on the east side of a desert range known as Spring Mountain, but the mine is situated on the west slope, 12 miles from Good Springs, by a road that crosses the range through a low pass.

The deposit on the Boss claim was discovered some 30 years ago, having been located for copper, the presence of which is plainly indicated by chrysocolla and other oxidized copper minerals. In the nineties the property was bonded and a leaching plant was built at Good Springs to treat the oxidized copper ore, but, the process proving a failure, the property reverted to its original owners. Not until recently has the gold and platinum content of the ore been recognized. The owners, Messrs. Yount and White, discovered the high gold content by sampling and assaying, and the Boss Gold Mining Co. was organized in March, 1914.

Prior to the discovery of the platiniferous character of the ore some small shipments of high-grade copper ore and of high-grade gold ore had been sent to the smelter at Salt Lake City, but after the platinum content was recognized, production was suspended, pending arrangement for the advantageous disposal of the platinum and allied metals.

In October, 1914, negotiations were under way for the treatment of certain lots of high-grade ore by the Pacific Platinum Works, of Los Angeles, whereby this firm agreed to pay $46 per oz. for the combined platinum and palladium content, after deducting a treatment charge of $300 per ton.

Late in 1914 the mine was sold by the Boss Gold Mining Co. to W. C. Price and associates for $150,000, according to O. J. Fisk, former manager of the company.

STATISTICS OF PLATINUM IN THE UNITED STATES

Year.	Production. (a)		Imports.			Total.
			Unmanufactured.		Manufactured.	
	Troy Oz.	Value.	Troy Oz.	Value.	Value.	Value.
1899	300	$ 1,800	187,778	$1,462,157	$ 55,753	$1,539,710
1900	400	2,500	118,919	1,728,777	36,714	1,767,991
1901	1,408	27,526	85,438	1,673,713	24,482	1,725,721
1902	94	1,814	105,450	1,950,362	37,618	1,989,794
1903	110	2,080	114,521	1,921,772	135,889	2,059,741
1904	200	4,160	103,802	1,812,242	105,636	1,922,038
1905	318	5,320	104,196	1,985,107	188,156	2,178,583
1906	1,439	45,189	137,556	3,601,021	187,639	3,833,849
1907	357	10,589	74,208	2,509,926	175,651	2,696,166
1908	750	14,350	50,768	1,096,615	134,119	1,245,084
1909	638	15,950	118,851	2,557,574	410,997	2,984,521
1910	773	25,277	120,478	3,320,699	333,965	3,679,941
1911	940	40,890	122,390	4,722,752	135,842	4,899,484
1912	1,005	45,778	104,683	4,334,488	159,995	4,540,261
1913	1,034	46,530	117,947	4,938,706	105,553	5,090,789
1914	3,430	154,350	72,267	2,934,580	39,143	3,128,073
1915	2,329	95,175	61,437	2,340,476	71,532	2,507,183

(a) Statistics of the U. S. Geol. Surv.

About 15 years ago sperrylite was also discovered in the copper ores of the Rambler mine, a short distance southwest of Laramie, Wyo. This attracted much attention, but the mine was quickly exhausted of high-grade material and production was stopped. Early in 1915 the mine was unwatered and development work has shown a large body of low-grade material that had previously been disregarded,[1] and the claim is made that the mine will again become an important producer.

World's Production

The world's output of new platinum, 1911–1914, is given approximately in the following table:[2]

WORLD'S PRODUCTION OF NEW PLATINUM IN 1911–1914, BY COUNTRIES
(In troy ounces)

Country.	1911.	1912.	1913.	1914.
Russia, crude	(*a*)300,000	(*a*)300,000	(*a*)250,000	(*a*)241,200
Canada, crude	(*a*)30	(*b*)30	50	(*a*)30
New South Wales and Tasmania, crude (*c*)	470	(*a*)778	1,275	(*a*)1,248
Colombia, crude	(*a*)12,000	(*a*)12,000	15,000	(*a*)17,500
United States, domestic crude	628	721	483	570
United States, refined from foreign and domestic matte and bullion (*d*)	(*d*)1,200	(*d*)1,300	(*d*)1,100	2,905
Borneo and Sumatra and other crude (*e*)	....	(*a*)200	200	(*f*)
Total	314,328	315,029	268,108	263,453

(*a*) Estimated. (*b*) In addition to platinum contained in matte and bullion refined in the United States. (*c*) Chiefly iridosmine. (*d*) Does not include refined platinum from domestic crude. (*e*) Includes small production in Madagascar. (*f*) No basis for estimate.

Australia.—The Tasmanian production of osmiridium dropped from about 1000 oz. in 1914 to 247 oz. in 1915. No figures are as yet available to show whether or not New South Wales equaled the 1914 production of 221 oz., but it is probable that there was a reduction, since there has been a decided drop in production during the last 3 years.

Canada.—During assessment work at the Quinn claims, in Munro township, Ontario, 1 mile east of the Croesus mine, platinum was discovered in commercial quantities. Five assays were made of ore taken at different places, the platinum content being stated to run between $180 and $1800 per ton. Traces of platinum have previously been found in the locality, but this is the first occasion in which it has been discovered in paying quantities[3].

The Canadian exports for 1915, according to the Preliminary Report of the Department of Mines, was 236 oz., valued at $11,052, contained mostly in bullion and copper matte refined in the United States.

Colombia.—In 1915 independent companies in Colombia furnished

[1] *Min. Sci. Press*, June 19, 1915.
[2] *Min. Res. of U. S.*, 1914.
[3] *Min. Sci. Press*, Jan. 22, 1916.

11,120 troy ounces of platinum to the United States, the greater part of the output of the largest single producer, the Anglo-Colombian Developing Co. goes to England. The declared value of the American shipments above noted was $506,566, or nearly $50 an ounce. At present from 1500 to 2000 ounces are produced monthly. The price which rose to $100 an ounce in December, 1915, fell to $80. by Jan. 22, 1916. It had again risen to $85., on March 1, in Cartagena the point of shipment; in the Choco market near the mines it ranged from $35 to $50. The Colombian production is one of rapidly increasing importance, as shown by the accompanying table.

UNITED STATES IMPORTS OF PLATINUM FROM COLOMBIA
(In troy ounces)

Year. (*a*)	Quantity.	Value.
1909	2,392	$36,440
1910	1,600	31,383
1911	5,503	147,820
1912	6,627	219,128
1913	10,461	363,731
1914	12,387	398,657

(*a*) Fiscal year ending June 30.

Two analyses of platinum from Colombia are interesting as showing the difference in allied mineral contents.[1] The first sample was of 15,460 oz. of platinum mineral and produced:

5.21 oz. platinum sponge,
4.47 oz. iridium,
0.47 oz. gold.

The second sample, comprising 6200 oz. of platinum-iridium mineral, gave:

3.36 oz. platinum,
0.11 oz. gold,
0.04 oz. iridium,
2.16 oz. osmiridium.

Russia.—Very little material is available concerning the conditions in Russia, and during the latter months of the year, practically nothing. The following from Ekaterinburg shows something of conditions at the middle of the year:

The production of platinum, since the outbreak of the war has, on the contrary, been on the decrease; thus, in actual figures, by comparing the output of the year 1914 with that of the preceding year, we find a decrease of 16,642 oz., the production for the year 1913 being 173,642 oz. and that of the year 1914, 156,775 oz. As soon as the war broke out the market for platinum—which is, of course, chiefly in France and Germany—being temporarily isolated from the producers, the outlook for the latter, especially the smaller ones, was extremely black. The Government, however, soon came to their assistance, offering £3 9s. per oz. on platinum ore at an annual rate of interest of 7 per cent. These terms, how-

[1] *Min. Jour.*, Mar. 13, 1915.

ever, were not good enough for some of the small producers, especially those working on placers by primitive methods, which some years ago would have been considered unworkable. These terms (mortages on the platinum) were eventually increased by the Government and private banks to £4 10s. per oz. at the same rate of interest—*i.e.*, 7 per cent. —half the year's interest being payable in advance. On these aforementioned terms about 46,240 oz. of platinum have been deposited in the various banks at Ekaterinburg, some of it having been forwarded to their Petrograd agents. The output during the year 1915 is estimated to be going to be about half that of former years, and, namely, between 86,700 and 104,040 oz. Although there is at present an embargo on the export of platinum (ore or mineral), permission can be, and has been, obtained from the Minister of Trade & Commerce in the event of export to friendly countries. For the month of July, 1915, however, there is to be an export duty on platinum ore which will probably be prohibitive (about 30 per cent.), which will necessitate the construction in Russia of refineries. Therefore, from this date platinum will be exported from Russia only in its refined state.[1]

The situation created by the present war would have formed an excellent opportunity for British platinum buyers to start an indirect business in the Urals—*i.e.*, buy direct from the Russian producers. To thoroughly understand the full advantages of this exceptional occasion it must be remembered that up till the war the French company (Compagnie Annonyme) always had a predominating interest in the platinum business, which practically amounted to a monopoly, having entered into agreement with the chief big producers for the exclusive purchase of their ware, besides being large producers themselves. Since the outbreak of the war, however, the French company have naturally been unable to meet their obligations of purchase, with the result that their former clients have been obliged to resort to the only way out of the difficulty—viz., mortgage their ore with the banks here. If a strong British organization were to come along, provided with sufficient financial strength, there is little doubt but that it could take up a monopolizing position in the platinum industry of the Urals, and it must be remembered that such a monopoly really means being in a position of dictating prices. The greatest difficulty, however, would seem to be the flatness of the demand on the markets abroad; however, owing to the reduced prices prevailing here now a strong financial group could well afford to wait till better times for selling their ore. One thing is, however, certain, and that is that if the British do not make a bold move while they have the opportunity there is no doubt that after the war the possibility of getting a firm footing and

[1] *Min. Jour.*, May 8, 1915.

direct business with the producer here will be lost, and they will again have to depend on buying refined platinum at an enhanced price in Paris.

The price prevailing now for small quantities of platinum ore—*i.e.*, from the small producers—is between Rs. 8 and Rs. 8.50 per zolotnik on a 83 per cent. basis platinum (at an exchange of Rs. 9.50 to £ sterling from 112s. 2d. to 119s. per oz. troy), but all the available platinum at this price is being brought up by local speculators, who are re-selling to Petrograd at prices commencing at Rs. 9 per zolotnik and over.

Considerable stocks are lying mortgaged at the various banks here (not less than 80 poods). The output for the current year is estimated to be very much less than former years.[1]

PRODUCTION OF PLATINUM IN RUSSIA

Year.	Official.	Actual.	Year.	Official.	Actual.	Year.	Official.	Actual. (c)
	oz.	oz.		oz.	oz.		oz.	oz.
1897	179,879	395,200	1903	192,976	226,000	1909	164,513	275.000
1898	193,213	203,100	1904	161,950	290,120	1910	176,334	300.000
1899	191,464	380,900	1905	167,950	200,450	1911	187,008	280.000
1900	163,060	212,500	1906	185,546	210,318	1912	177,596	300,000
1901	203,257	315,200	1907	172,064	310,000	1913	173,642	275.000
1902	197,024	380,806	1908	156,792	250,000	1914	156,775	240,000

PRODUCTION OF PLATINUM IN THE URALS
(In troy ounces)

District.	1908.	1909.	1910.	1911.	1912.
South Verchotur	97,747	100,986	111,070	121,317	118,281
North Verchotur	13,032	14,727	11,858	11,367	13,061
Perm	36,735	39,867	46,071	46,882	38,706
Tcherdinsk	7,452	7,161	6,361	(a)6,400	6,166
South Ekaterinburg	1,826	1,772	974	(b)1,042	(c)1,382
Total	156,792	164,513	176,334	187,008	177,596

(*a*) Estimated. (*b*) Includes 2 oz. from North Ekaterinburg. (*c*) 5 oz. from North Ekaterinburg.

At the meeting of the Russian Export Chamber on May 11, 1915, a report was presented on the work of the newly organized bureau for the gold and platinum industries, which has over 20 members. Some time ago an order was issued forbidding the exportation of raw platinum in quantities valued above 500 rubles ($257.50) in order that domestic refineries of the metal might be encouraged. However, not a single refinery has been opened, and the producers of platinum now have the metal on their hands and are unable to sell it. They have requested the bureau to find out whether or not sales of platinum might be organized in the United States. In case of an affirmative answer, the producers will ask for a modification of the embargo.[2]

[1] *Min. Jour.*, June 19, 1915.
[2] *Comm. Rept.*, June 15, 1915.

Spain.—According to a detailed account published in *Revista Minera Metalúrgica y de Ingeniería,* Madrid, Nov. 1, 1915, the presence of platinum has been definitely determined in some parts of the Ronda Mountains, in the province of Malaga, Spain.

In the course of a petrographic study of the rocks of the district by Domingo de Orueta, it was noticed that some of the rock bears a close resemblance to the platinum-bearing strata of the Urals, in Russia. The matter was followed up by careful sampling, during which platinum was actually found. The ground was then explored by boring, and the borings were washed. By this means pellets of platinum were found, together with the characteristic black sands, magnetite, chromite, etc.[1]

As regards the locality, the Sierra Nevada on entering the province of Malaga changes its E.-W. trend to one N.-E./S.-W., forming an abrupt slope between Malaga and Gibraltar. The end of the chain is called the Sierra de Ronda and contains several ranges of igneous rocks of the peridotite family, the most extensive covering 72 km. by 20. There are nine smaller masses in the same district of lesser importance.

The rock system has been the subject of careful observation and its analogy with that of the Urals noted, but it was left for Sr. Orueta, of the Mapa Geológico, to note the absolute similarity of the two chains. The peridotites of the Sierra de Ronda vary according to the proportion of basic and acid elements which they contain. The central mass is formed by the most basic rock dunite, which was the main object of Sr. Orueta's study. This dunite consists of a combination of olivine and chromite, the platinum being always associated with the latter. The metal is not concentrated as in the alluvial, but scattered throughout the mass.

The composition of the rocks having been studied and the most promising lodes determined, the presence of the metal had then to be verified, which was done by chemical and spectroscopic analysis. After this came the determination of the economic possibilities. By means of drilling the platinum zone was determined to lie 12 m. deep, with an average thickness of 1½ m. From this an ideal representation of the bed was made, with an estimate of the profitable tonnage. This has not yet been published, awaiting the verification of further work.

Of the samples obtained, one-third were rejected as too high owing to having picked up pure grains of metal. Of the remainder, a third gave from 2 to 3 gm. per ton of wash, another third from 0.25 to 2 gm., and the remaining third was considered too poor for treatment. Economic working of platinum sands may be said to begin from the level of 0.25 gm. It is also worth noting that as very little alumina is present, the treatment of these alluvials would be rendered cheap and easy.

[1] *Eng. Min. Jour.*, Dec. 18, 1915.

Sr. Orueta now proposes a fresh system of bores, taking advantage of his previous experience. A series of drills covering the whole field is to be undertaken, and if the results are satisfactory further bores, 200 m. apart, following the traversing lines of the river beds. The cost for a full study of the field is estimated at 300,000 pesetas spread over a period of 5 years. The great importance of the matter is fully recognized by the Government, which has furnished Sr. Orueta with all the necessary means for immediately continuing his work.[1]

Following the announcement by Sr. Orueta of the discovery of platinum in the Serrania de Ronda, there were two royal decrees in connection with it, demonstrating the interest taken in the matter by King Alfonso. According to *Madrid Cientifico*, Nov. 15, 1915, the first order charges the Geological Institute with the formation of a plan of operation for proving the platinum deposit and an estimate of the cost of the work. The determination of the extent of the field in which platinum may be found is also part of this work, establishing limits beyond which prospecting would not be justified.

The second order suspends prospecting in the Serrania de Ronda until the possible platinum field has been delimited as previously mentioned. This provides for a period in which the state may make its necessary investigations and possibly reserve all or a part of the district subject to special conditions.[2]

By a later decree the territorial limits of the mines are defined. Concessions to exploit the mines are obtainable from the Spanish Government, and these concessions are granted to foreigners as well as to Spanish subjects.[3]

So far as northern Spain is concerned, prospecting the gold and tin alluvials in that region has indicated that platinum will yet be found in payable quantities, as investigations carried out by drill and shaft sinking in the numerous river systems of the provinces of Orense, Lugo, Leon, Palencia, and Huesca have continually shown this mineral associated with gold in the river sands. Colors of platinum may be found in the rivers Miñho, Luna, Sil, Orbigo, Gallego, Cinca Darro, and lower Jenil; and though the mineral so far may not have been encountered in payable quantities, the inference is that its presence points to a source or origin (even if not in the immediate neighborhood) that may be worth thorough and scientific search. In the concentrate sands from pannings taken in the rivers previously mentioned may be invariably seen grains of magnetite, ilmenite, zircons, and platinum in thin flat scales.

While in Spain Mr. W. Dick, a London engineer, was a keen searcher

[1] *Min. Jour.*, Jan., 15, 1916.
[2] *Eng. Min. Jour.*, Jan. 15, 1916.
[3] *Comm. Rept.*, Dec. 14, 1915.

for the rare minerals which are found frequently associated with gold in alluvials, and in his reports in connection with the northwestern portion of the country mentioned the occurrence in small quantities of platinum in the gravels of the Rio Sil, near the villages of Quereño and Barco.

The late Mr. H. L. Lewis also reported the presence of platinum in sands of the Sil, near the ancient tunnel at Montefurado, but it is strange that at Toval de los Vados, above the three localities where some 180,000 cu. yd. of the Rio Sil gravels were treated by two different dredges at various periods, none of the ground worked proved sufficiently rich either in gold or platinum to warrant a continuance of mining operations, so that at all events it is evident that the gold-saving apparatus of the dredges failed to arrest platinum, which is significant, as the specific gravity of this mineral (varying from 14 to 19) is favorable for recovery by the ordinary gold-saving appliances of the modern dredge, and from this it may be presumed that the mineral, if present in the Sil, is not distributed throughout these alluvials in payable quantities for bucket dredging or sluicing.

The extent of alluvial in the Iberian Peninsula is enormous, and during the past 6 years, though some attention has been paid to the beds and banks of the numerous and important water courses where gold is distributed in the alluvia, but cursory investigation has been made for platinum deposits in this geologically interesting country.

In the Luna River district (Leon) small, irregular-edged flat scales of platinum were found, but not in any perceptible quantity, while testing the gravels for gold near Villaroquel. This river runs into the Omañes at Sacarejo, losing itself in the Orbigo; the wash is composed of old river drift, with outlying terraces at heights of from 200 to 400 ft. in reddish-colored formation of limestone, slate, and quartz gravel, frequently interstratified with bands of iron-stained clay. In the same river bed, above the village of Espinosa, bulk trials of sands from the same stream showed traces of osmiridium in small plates; also flat fragments of brookite, from a heavy, dark brown sand concentrate. Much higher upstream, in the long and deep gorge between Rioseco and Magdalena, it is obviously certain that if platinum exists it would be in a more concentrated form than lower downstream.

In the gravels of the Rio Gallego (Huesca), above Zuera, colors of platinum may be found invariably accompanying the fine gold existing in the river sands, but nothing less than boring will successfully test the deep-lying gravels of the Gallego. Further east, in the River Cinca, a water course flowing almost parallel with the Gallego, between the villages of Barbastro and El Grado, it is not an uncommon occurrence to find platinum in the river gravel, and though there are frequent belts of non-productive drift in the thick strata forming the upper Cinca valley, traces of both platinum and gold may be found at concentration points in the main stream bed, but no indication in the locality of any possible source of either mineral.

In the alluvial deposits of the River Darro (Granada), some distance above the present channel now being worked by native miners for gold, thin platinum flakes were found associated with gold in pan concentrates from the river bed, below a small series of chrome-bearing serpentine some miles east of the town of Granada, but such unfavorable ground conditions prevail that there are no possible means of working on any scale by hydraulic methods, even if any extent of the alluvial formation contained values.

The country generally has been imperfectly prospected for the rare minerals, and if the claims of Sr. Orueta prove to have substantial foundation, at least some of the alluvial districts of southern Spain may be most valuable, as at the present price of platinum 2 to 3 grains per cu. m. would be of unusual richness for gravels where suitable conditions prevailed for the working of bucket dredges or hydraulic plants in Spain, and it is manifest that the Spanish Government can well afford to undertake investigations over the areas where such values are supposed to exist and where fields offer any indication of permanence.

It will be beneficial to Spanish mining generally if Sr. Orueta's discoveries realize anticipations, but in the event of the finding of any field of sufficient richness to prove productive, more specially interesting will it be to watch the progress of the Spaniards who attempt any alluvial enterprise on a large scale, in view of the troglodyte laws, which up to the present time have so hampered the operations of foreign investors. In justice to the Spanish Mining Code, it is only fair to state that there are favorable factors in connection with alluvial mining in this country—viz., a nominal rent, and no limit to area located; but, generally speaking, there is a deplorable lack of impartial legislation in respect to private lands, expropriation, etc., which militates against prompt and decisive settlement on a fair basis.[1]

Substitutes

The high price of platinum during the past few months has given fresh impetus to the search for substitutes. Heyl patents[2] an alloy of palladium and silver to replace platinum for contact and spark points. Various percentage compositions are used for various requirements, 60 per cent. of palladium and 40 per cent. of silver showing the greatest resistance to spark erosion.

[1] *Min Jour.*, Dec. 11, 1915.
[2] U. S. Patent, 1166129, Dec. 28, 1915; *Met. Chem. Eng.*, Feb. 1, 1916.

Fahrenwald[1] finds alloys of palladium with gold and silver to be good substitutes for the softer forms of platinum, but for harder material, uses alloys of tungsten and molybdenum.

The substitution of osmium for iridium in the widely used platinum alloy has been proposed. It has been found that alloys with 6 to 10 per cent. of osmium are as available for electrical apparatus as those with 15 to 25 per cent. of iridium. The platinum-osmium alloy while it has equal ductility, resists more effectually the action of acids than does the platinum-iridium alloy.

An alloy composed of palladium and rhodium, in the proportions of 90 per cent. of the former and 10 per cent. of the latter is about to be used by the German jewelry industry. While these are both platinum metals, the specific gravity of the alloy is only about one-half that of platinum, being but a trifle more than that of silver. As rhodium commands a higher price than platinum the composition will be worth something more per gram. However, because of its lower specific gravity, the metal value of a finished article will be lower. The necessity of finding a substitute for platinum has become urgent in Germany, as the Government contemplates placing the entire stock of this metal under requisition

[1] *Bull. Amer. Inst. Min. Eng.*, Jan., 1916, p. 103.

POTASSIUM SALTS

By J. W. Beckman

The potash situation all over the world labored during 1915, under extreme conditions. Due to the war, with accompanying embargo on all potash salts produced in Germany, the activities of the world have been crippled in more ways than one.

In many cases, the agricultural industries are doing without any potash, while in other instances some minerals containing a small amount of potash are mixed with the other fertilizer ingredients, more for the purpose of being able to advertise a potash-content than for the actual value and availability of the potash.

Under these extreme conditions every source of potash has been put to a test.

The extremity of the situation is readily realized when it is appreciated that only 203,711 tons of potash salts used for fertilizer purposes (equivalent to 80,082 tons K_2O) were imported during the year ending July 1, 1915, to United States, while during the year ending July 1, 1914, there were imported German potash salts for fertilizers, aggregating 1,066,929 tons gross (equivalent to 256,920 tons K_2O). At the present rate only 30 per cent. of the potash salts imported to United States before the war, reach this country.

Prospects are very small for any radical change in the potash situation as to imports to United States before the war comes to an end.

IMPORTS OF POTASSIUM SALTS (*a*)
(Tons of 2000 lb.)

	1911.		1912.		1913.		1914.		1915.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bicarbonate	163	$ 16,428	138	$ 13,155	156	$ 14,295	239	$22,767	383,534	20,341
Carbonate (crude)	5,340	327,400	3,299	207,417	5,032	295,066	4,523	240,451	8,620,504	291,341
Carbonate (refined)	5,572	395,728	5,313	383,958	7,018	412,587	5,211	368,858	2,377,940	92,959
Chloride	214,283	6,449,575	242,033	7,235,728	223,837	6,737,757	263,039	7,925,781	102,732	3,666,118
Chlorate	12	2,096	21	3,444	618	66,609	20	3,408	27,419	4,614
Chromate	11	1,699	22	2,273	14	2,601	17	2,822	40,227	3,317
Cyanide	1,163	326,973	1,048	312,777	475	137,535	618	183,259	747,627	143,331
Hydrate (crude)	3,713	309,965	4,211	330,684	4,497	348,500	4,283	336,650	....	....
Hydrate (refined)	41	9,254	39	8,096	56	11,919	9	1,977	....	....
Kainit	656,842	2,637,106	479,817	2,400,590	466,184	2,149,689	589,245	2,579,619	79,001	444,769
Nitrate (crude)	4,645	282,835	3,086	213,258	5,495	288,995	1,764	115,470	677,785	22,483
Nitrate (refined)	426	38,384	221	23,896	197	22,142	182	20,173	34	4,222
Prussiate (red)	27	10,230	35	11,264	33	11,03	45	15,325	83,574	14,922
Prussiate (yellow)	889	180,584	1,036	203,295	1,406	309,309	1,754	390,021	2,316,736	255,711
Sulphate	53,135	1,952,371	50,551	1,853,236	48,023	1,798,362	50,384	1,887,491	21,852	1,071,761

(*a*) For the fiscal years ending June 30.

The potash syndicate has published the figures on the total world's sale for 1915, which are bound to be of general interest: the grand total amounts to 680,000 metric tons actual potash (K_2O) in 1915, as against 904,000 metric tons actual potash (K_2O) in 1914.

The official estimated sales for the year 1916 is 714,000 metric tons actual potash (K_2O) of which 589,000 metric tons are calculated to be for domestic consumption and 125,000 metric tons actual potash (K_2O) for shipment to foreign countries.

The apportionments to the different mines for 1916, have been affected accordingly.

The estimate for 1915 was 562,000 metric tons actual potash (K_2O) for domestic consumption and 386,000 metric tons actual potash (K_2O) for foreign countries.[1]

The production of potassium salts in Germany in recent years, is shown in the following official table:

PRODUCTION OF POTASSIUM SALTS IN GERMANY. (*a*)
(In metric tons and dollars; 1 mark = $0.238)

Year.	Kainit.		Potassium Salts Other than Kainit		Potassium Chloride.		Potassium Sulphate.		Potassium Magnesium Sulphate.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
		$		$		$		$		$
1898	1,103,643	3,835,856	1,105,212	3,576,628	191,347	6,380,220	18,853	763,397	13,982	259,485
1899	1,108,159	3,838,250	1,384,972	4,202,000	207,506	6,801,250	26,103	1,027,500	9,765	195,000
1900	1,178,527	4,134,000	1,874,346	5,643,750	271.512	8,793,750	33,853	1,249,250	15,368	280,500
1901	1,500,748	4,327,250	2,036,326	5,443,250	282,750	8,782,250	27,304	1,460,000	15,612	286,500
1902	1,322,633	4,571,980	1,962,384	4,949,448	267,512	7,507,710	28,279	1,079,092	18,147	334,390
1903	1,557,243	5,208,154	2,073,720	4,993,478	280,248	8,125,320	36,674	1,389,444	23,631	441,252
1904	1,905,893	6,322,470	2,179,471	5,305,972	279,238	8,425,676	43,959	1,664,572	29,285	545,972
1905	2,387,643	7,976,808	2,655,845	6,396,250	373,177	10,580,528	47,994	1,804,040	34,222	614,754
1906	2,720,594	8,918,574	2,821,073	6,538,336	403,387	11,034,632	54,490	2,032,520	35,211	644,028
1907	2,624,412	8,579,206	3,124,955	7,314,930	473,138	12,639,704	60,292	2,216,494	33,368	631,652
1908	2,715,487	9,196,082	3,383,535	7,720,006	511,258	13,369,174	55,756	2,037,518	33,149	663,068
1909	3,181,349	10,646,792	3,860,685	8,787,198	624,994	16,245,642	68,539	2,574,684	38,722	697,816
1910	4,249,667	12,712,056	4,062,004	9,034,004	741,259	17,371,144	84,583	2,989,756	37,439	668,066
1911	4,425,497	13,757,452	5,181,379	11,794,328	838,420	19,851,342	107,631	3,967,460	42,253	780,974
1912	5,889,238	18,178,916	5,271,964	10,294,214	506,744	16,336,792	123,407	4,848,714	54,435	(*b*)
1913	....	....	....	....	....	....	....	....	......	......

(*a*) From *Vierteljahrshefte zur Statistik des Deutschen Reichs.* (*b*) Value, $1,052,912.

Exports from Germany during 1912 and 1913 are given as follows:

Articles.	1912.		1913.	
	Metric Tons.	Value.	Metric Tons.	Value.
Carnallite with at least 9 per cent. and less than 12 per cent. K_2O.	6,853	$46,000	520	$3,000
Raw salts with 12 to 15 per cent. K_2O..............	853,117	4,094,000	1,124,816	6,697,000
Salts with more than 15 to 19.9 per cent. K_2O.......	35,530	286,000	49,687	404,000
Fertilizer salts, including potash fertilizer, with 38 per cent. K_2O.	373,685	5,510,000	460,865	7,855,000
Chloride of potash, not in shells or capsules..........	1,068	158,000	1,164	166,000
Sulphate of potash................................	85,749	3,660,000	133,358	5,700,000
Sulphate of potash-magnesia........................	48,600	1,085,000	59,207	1,339,000

[1] *Amer. Fert.*, Mar. 18, 1916, p. 31.

Due to the war all countries having even a faint tract of available potash deposits have been carefully studied by the individual, or government and private interests. So far the results obtained have not been encouraging. The most promising deposit is the Spanish deposit.

For fear that the potash deposits in Spain might come completely under foreign control (and it has been reported that the German Syndicate has partly succeeded in obtaining controlling interest in some), the Spanish government has, on this account, drafted a law which permits the State to intervene for the purpose of protecting the supply and its consumption.[1]

The stoppage of shipments of potash salts from Germany by the war has called attention to the potash deposits that were known to exist near Barcelona. Borings and analyses had been repeatedly made with reference to the region where the salts abounded in the Spanish provinces of Barcelona and Lerida. The results have been particularly favorable, but it will require the employment of capital and enterprise to make potash in this neighborhood a commercially profitable product.

In the various borings near the town of Sarria potash salts were found at depths between 121 and 197 ft., and another deposit at 426 ft. At 886 ft., the greatest depth attained, important quantities of potassium compounds were found to rest on a stratum of white salt not yet pierced. In the area tested by borings comprising some 2,690,000 sq. ft., there were estimated to be approximately 2,550,000 tons of carnallite and 1,150,000 tons of sylvinite, which should produce a total of 3,675,000 tons of potassium salts.

From the general characteristics of the region it is considered probable that there are further deposits in greater or less proximity to those already tested. In a stream running by the salt works of Cardona there is a large percentage of potash in solution, and it has been discovered that quantities of potash have already been allowed to go to waste in the salt mines that might have been profitably used.

On account of the exceptionally irregular geological formation of the country near Barcelona it is difficult to make exact valuations of the amount of potash salt that can be mined. Nevertheless, the presence of certain gypsum beds and the potash-holding streams will serve as a guide to determine the continuation of the potash deposits.[2]

Other Foreign Sources.—Changes which have occurred in the potash industries of other foreign countries have been mainly due to lack of competition with the German potash salts. In general all known sources of potash have been developed.

[1] *Comm. Rept.*, Aug. 13, 1915, p. 739.
[2] *Min. Jour.*, Aug. 14, 1915, **100**, p. 262.

At various places as in Norway, Scotland and Japan, some potash has been made from kelp ashes. In other countries, waste from distilleries, beet-sugar factories, and wool washeries, have been treated, making the potash-content in same available. Nitre deposits from India, Chile and Africa furnish potash salts in relatively small amounts. Potash in Chile is not a novelty, since specimens of salts containing 16 per cent. and 28 per cent. of KCl were shown at the Chilean pavilion at the exposition held there in 1907. The potash salts are found in the Province of Tarapaca, Chile, in Pintados and Bella Vista Lakes, with an area of 10,000 acres. The deposits are only 3 miles from the railroad that runs from Iquique to Lagunas. The potash occurs as chloride in a crust at the surface, samples of which vary from 3 to 36 per cent. of KCl. The density of the bed is about 1.352. This superficial crust varies, having an average thickness of 20 cm., but this is only a part of the potash contained in these lake beds, as the water underlying the crust contains the same salts (8 kg. of potassium chloride per cubic meter of brine), which by evaporation and capillarity have formed the salt crust.

One-third of all the chloride of potassium sold in Europe is used for the manufacture of potassium nitrate from the nitrate of soda imported from Chile. These two salts being only a few miles distant in the Province of Tarapaca, the benefits that can be derived are obvious. To make 100 kg. of potassium nitrate it is necessary to use 73.95 kg. of chloride of potassium and 84.15 kg. of nitrate of soda (Chile saltpeter). Hence it would be easy to undertake this manufacture in Chile. A freight of 58 kg. on inert substances would be eliminated for each 100 kg. of nitrate of potash exported.[1]

Potash Deposits in United States.—With the greater part of the imports of potash to United States cut off, and with chemical industries and especially explosive industries operating at unprecedented rate, there has followed a shortage in potash, to the extent that it is feared that if no relief is effected, it may seriously influence the crops from the soil.

The most encouraging features in the situation are two different developments, developments which indicate permanency even after the war has ended, and promising to make United States, to some extent, if not completely, independent of the German potash. These two sources are alunite and kelp from the Pacific Coast, both of which are being treated and are supplying some potash.

Alunite is a hydrous potassium aluminium sulphate, insoluble in water. If this compound is calcined at a high temperature the aluminium sulphate decomposes, leaving soluble potassium sulphate, with insoluble

[1] Potash Deposits in Chile, by Severo Salcedo, *Eng. Min. Jour.*, **100**, p. 218.

aluminium oxide. The potassium sulphate is recovered by means of leaching and evaporation and is then suitable for various purposes. The aluminium oxide is obtained in a practically pure condition. These deposits are very extensive and the only potash production of any magnitude in the United States uses alunite as a raw material. The Minerals Products Co., of New York have a mill in operation at Marysvale, Utah, and a number of other mills are being erected in the same locality.

Alunite deposits are found in various other states, and in Nevada it is reported alum occurs from which preliminary tests have been made for potash recovery.

Kelp.—The Pacific Coast of the United States and Alaska, as well as places in the North Atlantic, have large and abundant fields of sea kelp. The kelp has the remarkable faculty of absorbing potash present in sea water. Different types of kelp contain different quantities of potash. The following shows the extreme contents of Pacific Coast kelps:

COMPOSITION OF KELP (FRESH MATERIAL)[1]

	Per Cent.	
Moisture	91.37	84.66
Nitrogen	0.35	0.08
Phosphoric acid (P_2O_5)	0.14	0.04
Potash K_2O	2.45	1.58
Iodine	0.04	0.006

The kelp if cut with care about 6 ft. under the surface of the water, will grow again and can be harvested again in 6 months.[2]

The Hercules Powder Co. have erected a plant on San Diego Bay, to produce 40 tons of potassium chloride per day from kelp.

Swift and Co., as well as other concerns, at various points on the Pacific Coast, are erecting plants, or are already operating them.

It is shown that potash can be obtained from kelp, provided operations are carried out on a large scale, at prices that would make this potash recovery commercially feasible, even when potash is down to pre-war prices.

Saline Deposits.—It is more and more apparent that the Searles Lake is not the only saline deposit containing potash. Up to the present time it has held the most prominent position and it is doubtful if it is just.

Various localities have been drilled in the arid sections of United States, and encouraging indications of potash have been encountered.[3]

The work on the Searles Lake potash is progressing slowly, though it is reported that potash from this source can be counted upon in the near future. Some secrecy surrounds the latter developments of this oper-

[1] The Economic Value of Pacific Coast Kelp, by John S. Burd. *Bull.* **248**, College of Agric., Berkeley, Cal.

[2] Potash from Kelp, by J. F. Lancks, *Met. Chem. Eng.*, Mar. 15, 1916.

[3] Potash in the Texas Permian, by J. A. Udden, *Bull.* **17**, University of Texas, 1915.

ation. Reports state that the brine will be pumped in a pipe line to a suitable point on the coast, and at such a point the separation of various salts will be effected.[1]

Potash-bearing Solutions.—In the solar evaporation of sea water for the production of salt, a brine known as "bittern" is obtained as a mother-liquor, containing various salts, together with considerable quantities of potash salts. This potash-content is being recovered as well as the potash-content present in the waters of the Great Salt Lake of Utah.

Potash-bearing Waste.—In Europe it has been common practice for a long time, to avoid polluting rivers and water courses, by means of sugar-house and distillery refuse, to treat these for the recovery of their potash-content, and in such manner avoid admitting the offensive fluid to rivers.

Plants for the recovery of potash from these waste liquors are being installed in different parts of the country, especially in the sugar-producing districts. The South and Pacific Coast, have seen some developments along these lines.

Potash is also being recovered from the refuse of wool washeries.

Potash-bearing Minerals.—A company controlled by one of the large fertilizer companies in the South, is attempting to obtain potash from feldspar, according to the Cushman process. Small operations for the same purpose are being projected and operated in various parts of the country.

Cement Dust.—One of the accompanying evils of a cement plant is the dust which is emitted into the air, together with combustion gases from the kilns. This has caused considerable annoyance in the past. It has been shown that the potash-content of raw materials entering into the manufacture of cement, is volatilized and carried off in the smoke.

Through the efforts of the Western Precipitation Co., and the application of the Cottrell electric precipitation process to this dust, a material with 20 per cent. available potash is obtained.

A number of cement plants are being equipped with electrical precipitator for potash recovery and it is more than likely in the future that when a cement plant is being projected, the potash-content of its raw materials will be a determining factor in its location.

Tailings from some copper ores contain, in many cases, considerable amount of potash. Investigations have been made in various copper districts with encouraging indications.[2]

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[1] W. B. Hicks, U. S. Geol. Surv., *Professional Paper* 95-A.
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PRECIOUS STONES

By George F. Kunz

The harmony of a color scheme has such high artistic value, that more attention could well be paid in the selection and wearing of gems to their color-harmony with the costumes of the wearer and with the color of the latter's hair, eyes and complexion. Much attention was being given to this in the great cities, Paris, Vienna and Berlin, before the war, and with the great revival of trade sure to follow the conclusion of peace, the interest of the purchasers of precious stones will be more and more directed to the matter. Of course, the diamond and the pearl are in harmony with any and all colors and shades, but with the colored stones there is great opportunity for the exercise of artistic taste in suiting the gems to the gowns with which, or on which they are to be worn. Moreover, anyone whose color-perception is fully developed must know and feel that for women of a certain shade of complexion, hair and eyes, sapphires and other blue stones will be more especially beautiful, while with others rubies and the many red or deep-pink stones will be much more in harmony.[1] A writer suggests that deep-hued gems prove an attracting contrast with paler hued fabrics of the same color, and also recommends rubies or rubellites with pink-and-white striped gowns; amber goes with buff and blue or with multicolored stripes.[2]

In the past year many diamonds have been cut in the emerald or degree form of cutting, that is, square with the corners removed, making an octagonal stone; some are square, others cut oblong, and frequently the oblong stones are worn set crosswise on the finger.

Colored beads of all varieties of stones are still in great demand. Rock-crystal plaquettes with small borders etched or engraved with a dull relief or in bright relief are used in many forms. This extends to the making of cigarette cases, match cases, watch cases, etc., the material being engraved, and being given an engine-turned effect by etching.

Turquoise, which has been found in America in such great beauty in New Mexico, Arizona, Nevada and California, has been very slightly mined recently, because the stone has not been received with much popular favor in the United States, except for the cheaper jewelry, wherein

[1] An interesting contribution to this subject is Lillian Purdy Goldsborough's "Matching Fabrics with Precious Stones," *Jeweler's Circular-Weekly*, Dec. 29, 1915; first pub., Oct. 16, 1907.

[2] Isabelle M. Archer, "Suggestions for Gems with the Latest Modes in Dress," *Jewelers' Circular-Weekly*, June 14, 1916.

the paler or discolored varieties are used in great quantities, principally in what is known as a form of turquoise matrix. They are frequently set in silver by the Armenians and by the Navajo Indians of Arizona and New Mexico.

Magnificent crystals of red and pink tourmaline (rubellite) have been found in Pala, San Diego County, Cal., some weighing 2 to 4 lb. each, in part of perfect form. A great many of these have found a good market in China where they, as well as crystals of amethyst, chalcedony, rock crystal and other semi-precious stones, have been cut into many quaint forms, made up of fruits, insects and other objects constituting Chinese symbols. These are quite as well cut as the older examples of this work and have found a ready sale in many countries.

Many interesting minerals were shown at the Pan-American Exposition at San Francisco during the duration of the Fair, from February to December, 1915. One great collection of semi-precious stones in their natural state, was shown in the form of crystals, fractured pieces, or rolled pebbles; cut stones illustrating the many forms of cutting, the variety of color, and the various methods of lapidary working, were exhibited by Messrs. Tiffany & Co., at the request of the Department of Mines. Among other interesting things were a fine series of black opals from New South Wales; opals from Nevada; a gem mine made up of the various rocks and mineral forms in the cavities of a mine at Pala, Cal.; sapphires from Queensland, Australia, and Maori gems and jade from New Zealand.

At the California midwinter exposition at San Diego, a very important collection of tourmaline and kunzite, fully illustrating all the forms of that material as found at Pala, San Diego County, and a large exhibit in the form of a model of a gem mine of the associated minerals as they were found in their original state, were the special features.

The United States to-day possesses greater collections of precious stones than any other nation; especially the Morgan Collection in the American Museum of Natural History, the collection in the Field Museum of Natural History in Chicago and in the United States National Museum in Washington, the New York State Cabinet Collection shown at Albany, the Golden Gate Museum Collection at the Golden Gate Park, San Francisco, Cal., and more recently, a collection of about 1000 specimens at the Oakland, Cal., Public Museum.

A little work that will appeal to a wide range of readers is "Gems" by Helen Bartlett Bridgman.[1] Here many items of general interest concerning precious stones are very skillfully and pleasantly imparted, and while treating her fascinating subject in a popular way, the author has been careful to consult the best authorities, and has

[1] Helen Bartlett Bridgman, "Gems," Brooklyn, N. Y., 1916, 117 pp., 8 vo.

thus been able to group together under the different separate headings matters that will be eagerly read by all devotees of gems and jewels.

Many data of interest regarding precious stones are contained in the present writer's companion volumes, "The Curious Lore of Precious Stones," and "The Magic of Jewels and Charms," published respectively, in 1913 and 1915.[1] The copious indexes make it easy to find the numerous notices of diamond, emerald, ruby and sapphire, turquoise, and other precious stones. The electric properties of tourmaline, as well as of lodestone and amber are treated of at considerable length,[2] as are also the phosphorescent and fluorescent qualities of diamonds and certain other precious stones.[3]

Governmental Regulations

Very strict regulations have been made in England to prevent rough diamonds or bort from coming into the hands of the Germans. In order to relieve the situation as much as possible for French diamond cutters it has been provided that the interested parties shall address their requests to the French Embassy in London, along with a formal engagement of non-exportation. This must be countersigned by the Chambres Syndicales to which the applicants belong. The English sellers have to lay the matter before the "Diamond Export Committee."[4]

Great Britain's embargo on the exportation of diamonds for industrial use has been made operative here. Importers of this class of diamonds from Great Britain are required to sign an agreement not to export them, directly or indirectly, to any country at war with Great Britain. Moreover, any material of this kind exported to the United States from Holland or elsewhere must be consigned to the British consul general in New York, and the agreement furthermore provides that all industrial diamonds sold to persons outside of New York must be entrusted to a designated person in that city chosen as its representative in this respect by the British Government. Failing the acceptance of these conditions, the purchaser may not be able to release his goods from the custody of the British consul in New York.[5]

The full text of these forms of agreement may be worth printing here as a record and for its historic interest.

[1] George Frederick Kunz, "The Curious Lore of Precious Stones," J. B. Lippincott Co., Philadelphia and London, 1913, xiv + 406 pp., 61 pl. (6 in color) and many text cuts, 8 vo. "The Magic of Jewels and Charms," J. B. Lippincott Co., Philadelphia and London, 1915, xv + 422 pp., 58 pl. (8 in color), many text cuts, 8 vo; also a small volume on The Precious Stones of Shakespeare with several plates.

[2] "Magic of Jewels and Charms," pp. 51-71.

[3] "Curious Lore of Precious Stones," pp. 158–175, esp. 168–174.

[4] Recueil Mensuel des Procés-Verbaux des Séances de la Chambre Syndicale des Négocians en Diamants, Perles, Pierres Précieuses et des Lapidaires, Paris, Dec., 1915–Mar., 1916, pp. 486, 487.

[5] *Jewellers' Circular-Weekly*, Jan. 19, 1916.

DIAMOND GUARANTEE

HIS BRITANNIC MAJESTY'S CONSUL GENERAL,

NEW YORK.

Shipper........................

Sender........................

From........................

Parcels........................

Weight........................

Marks........................

In consideration of your consenting to the delivery to us of the industrial diamonds specified in the margin, we

hereby give you the following undertaking which shall remain in force so long as Great Britain continues at war with any European Power:

That the diamonds if released will only be sold or disposed of by us for industrial purposes in the United States, and will not be exported, or sold for export, directly or indirectly, to any country at war with Great Britain.

We further undertake not to dispose or sell the diamonds now released or any other industrial diamonds which may now or hereafter be in our possession to any person in the United States other than legitimate American users of such diamonds, whose guarantee to your satisfaction against the re-exportation or re-sale of the same we will produce to you within seven days from the date of sale.

We further agree that when we make any sale of industrial diamonds to any users, it will be made an essential condition of the Sales Contract that the purchaser will make, on the stamped paper of his firm and before a Notary Public, a sworn statement to the effect that the diamonds so sold to him are actually in his possession and that such sworn statement will be sent to the British Consulate General by registered mail within forty-eight hours after the diamonds shall have reached him.

We further undertake to produce on demand, for the confidential inspection of the British Consul General, the firm's sales records or other documents showing the disposal of the diamonds above referred to.

We further undertake in the event of our importing any diamonds from Holland, or other countries than Great Britain, that we will have the same consigned to the British Consul General at New York to be released under similar conditions.

DIAMOND GUARANTEE

HIS BRITANNIC MAJESTY'S CONSUL GENERAL,

NEW YORK.

Shipper........................ In consideration of your consenting to the delivery to us of the rough diamonds specified in the margin, we

From........................

Parcels........................ hereby give you the following undertaking, which shall remain in force so long as Great Britain continues at war with any European Power:

Weight........................

Marks........................ The diamonds specified in the margin will be used exclusively for the purpose of being cut and polished into brilliants, and none of these diamonds will be sold or otherwise disposed of in the rough state, and they will not be sold or otherwise disposed of in a finished condition, directly or indirectly, to any country at war with Great Britain.

We further undertake in the event of our importing any diamonds from Holland, or other countries than Great Britain, that we will have the same consigned to the British Consul General at New York, to be released under similar conditions.

....

Date........................ ....

DIAMOND GUARANTEE

HIS BRITANNIC MAJESTY'S CONSUL GENERAL,

NEW YORK.

Shipper........................ In consideration of your consenting to the delivery to us of the polished diamonds specified in the margin, we

Sender........................

From........................ hereby give you the following undertaking which shall remain in force so long as Great Britain continues at war with any European Power:

Parcels........................

Weight........................ We will not sell or otherwise dispose of the diamonds now delivered by you, directly or indirectly, to any country at war with Great Britain.

Marks........................

We further undertake in the event of our importing any goods from Holland, or other countries than Great Britain, that we will have the same consigned to the British Consul General in New York to be released under similar conditions.

We further undertake that all goods sent from Holland shall be passed and sealed by the Jewellers' Association before they are despatched to this country.

....

Date........................ ....

In the Union of South Africa an export tax on diamonds was imposed from May, 1916. The provisions of the act are designed to place the burden upon the most profitable undertakings and more especially upon the De Beers company. The initial provision is that all diamonds found in the country shall be registered, a registration fee of ½ per cent. being imposed on their value. When exported, this registration valuation is taken as the standard for the duty, which is to be levied on the sum of annual exports, but only in case the gross profits of the undertaking, as assessed under the Mining Taxation Act of 1910, are shown to have exceeded 35 per cent. For every ¾ per cent. over this a tax of ½ per cent. is imposed, up to a maximum tax of 5 per cent., which would have to be paid when the profits had exceeded 41¾. The tax, when imposed, is, however, payable on the whole profits, not merely on the excess profits over 35 per cent. or over either of the successive grades of profit. Hence, if a single company whose books showed a profit of 42 per cent. exported in a year diamonds to the value of £2,000,000, the 5 per cent. maximum tax would amount to £100,000. This can scarcely be regarded as a temporary war measure, for the immediate returns will be comparatively small as compared with those that must be realized when the flood-gates of diamond exportation will again be opened following the active mining that is sure to ensue not long after the conclusion of a world peace.

In November, 1915, permission was given to resume diamond mining at Luderitzbucht in the German Protectorate of Southwest Africa, now occupied by the English. The condition was imposed that the collective product of all the mines should not exceed 10,000 carats a month. This would mean a rate of 120,000 a year, a quantity far short of the German limitation of 1,000,000 carats. Of course, the leading diamond enterprises of South Africa would hardly welcome a large production from these Luderetzbucht deposits in present competition with their own stocks, or with their product when mining operations shall have been taken up again in the great De Beers' and Premier mines. At present the revived American market affords the opportunity of disposing of the stock accumulated in the hands of the Diamond Syndicate, but until general economic conditions have so adjusted themselves as to afford some assurance of a permanent demand, the diamond interests are disposed to proceed with great caution.[1]

A duty of 7½ per cent. has been imposed in India on imports of precious stones. It is claimed that this has checked the export trade to that land from London, which might otherwise perhaps have been an important outlet for the London dealers. The restrictions upon the importation of small diamonds to England, in the effort to shut out German

[1] *So. Afr. Min. Jour.*, Feb. 26, 1916, pp. 591, 592.

material that might be surreptitiously introduced has made it somewhat difficult for the dealers to secure this grade of diamonds.

To prevent the exportation from Holland of any of the German Southwest African stones in German hands, the British Government requires that a certificate be presented for legalization to the British consulate in Amsterdam, showing that the cutting of the stones to be imported has been done in Holland from other than Southwest African material. The Post Office is authorized to hold up any consignments lacking such certificates. On the other hand, stringent regulations govern the export of rough diamonds from England, lest any should fall into German hands. The supervision of these exports is confided to a Government commission, every parcel consigned being carefully examined as to sender and consignee. Moreover, in the case of diamonds exported for cutting, a deposit of 25 per cent. of the value must be made, to be refunded when proof is submitted that the stones have been cut. Bort may be exported only in the form of diamond dust, only available for polishing, lest this industrially valuable material should come into Germany.

The practical help given to diamond dealers in the present crisis by the Dutch Government is well worthy of commendation. A Trade Protection Committee has been appointed to report on the credits that can safely be assumed by the small diamond dealers, and one-half of this credit-risk will be guaranteed by the State, the total of credits not to exceed $500,000, of which the Government would thus guarantee $250,000.

Trade Conditions

The entire mining system being closed down at the beginning of the war and the demand for diamonds gradually increasing due to awakening of the American industries, the diamond syndicate made three successive increases affecting the price of cut diamonds of all sizes, which were very uniform as regards all except those weighing 1 carat or less. For those over 1 carat and up to 5 carats in weight, the first raise in price, Nov. 22, 1915, was 4¾ per cent., the second, 5 per cent., and the third increase, 11 per cent., in all 20¾ per cent., more than one-fifth, in a little over 3 months' time. The advance for rough diamonds was about 40 per cent. higher. For the smaller stones the increases were as follows:

	⅜ Carat, Per Cent.	½ Carat, Per Cent.	¾ Carat, Per Cent.	1 Carat, Per Cent.
Nov. 22, 1915	....	2¾	3½	4¾
Jan. 7, 1916	1½	4	4	5
Feb. 2, 1916	3	4	6	9
	4½	10¾	13½	18¾

The relatively slight increases in the very small stones has been thought by some to have been determined by a wish to keep out of the market the many South-West diamonds now held by the Union of South Africa. These diamonds from the old German fields, while of excellent quality, are with few exceptions small stones.

The local exchange for the diamond trade in London, Hatton Garden, is thronged with Belgian dealers, who are willing to close their transactions quickly, contenting themselves with a small profit. The Amsterdam market is kept active, and there has been more or less speculative buying by Americans, who wish to take advantage of a rise in the price of rough diamonds, as the material already cut can be sold at a lower figure than that to be cut later from higher-priced stones in the rough.

Diamond cutting in London has received quite an impetus through the Belgian refugees, several of whom have opened diamond-cutting establishments in that city. At the present time there are said to be about 200 diamond workers of all nationalities employed in London, a number of them being members of the London Diamond Workers' Union.

It is worth noting as one of the curious effects of the war in London trade, that the present demand for cheap diamond rings, such as are sold by East End jewellers, is phenomenally large. This is due to the exceptionally high wages earned by many British workers in the special industries, and also to their inclination toward free spending of their money.[1] On the other hand, the demand for the larger diamonds has fallen off greatly in England, since the wealthy classes have suffered a very considerable decline of income, due to industrial derangement, and above all, to heavy taxation. In Birmingham also the trade in low-priced diamond rings is exceedingly brisk.

"It is an ill wind that blows no one good," and the misfortunes that have overtaken Belgium have advantaged the diamond industry in Amsterdam, where in recent years the successful competition of Antwerp was becoming more and more keenly felt. Of course, at the outset, the diamond trade of Amsterdam too was involved in the general prostration of this branch of industry, but with a renewal of activity in this direction, most of the benefit falls to the share of the Dutch city, whose great rival is practically put out of competition.

Market and Imports

A striking illustration of the extraordinary recovery of the market for precious stones is given by the figures for imports into the United States in May, 1916, compared with those for the same month in the years from

[1] W. A. Doman, "The Diamond Trade in 1915," *African World*, Dec., 1915, p. 158.

1898 to 1915. It will be noted, in comparison with the record figure of over $5,000,000 for last May, that a total of over $4,000,000 has only been twice realized, in 1913, owing to the stimulation of buying in view of the approaching rise in the rates of duty, and in the great "boom" period of 1906:

May.	Uncut.	Cut.	Total.
1898	$134,909.40	$202,759.85	$337,660.25
1899	432,851.45	1,200,711.59	1,723,563.04
1900	513,597.85	804,761.16	1,318,359.01
1901	1,235,877.78	1,944,385.37	2,180,273.15
1902	889,229.02	1,386,647.04	2,275,946.06
1903	567,086.18	1,885,497.78	2,422,583.96
1904	1,051,594.42	1,328,241.59	2,379,836.01
1905	972,918.95	2,260,906.36	3,233,825.31
1906	1,347,862.10	2,673,542.96	4,021,405.06
1907	624,829.00	2,350,606.00	2,981,435.00
1908	176,146.08	287,308.77	463,454.85
1909	721,697.62	1,967,515.87	2,689,213.49
1910	790,369.25	1,926,712.79	2,717,082.04
1911	653,330.35	2,010,499.05	2,663,829.40
1912	880,659.00	2,129,680.00	3,010,339.00
1913	1,115,037.00	3,491,286.00	4,606,323.00
1914	344,739.00[1]	1,685,016.00	2,029,755.00
1915	658,844.00[1]	794,708.00	1,453,522.00
1916	1,040,102.00[1]	3,983,524.00	5,023,626.00

[1] This includes precious stones to be used for mechanical purposes.

IMPORTS OF DIAMOND AND OTHER PRECIOUS STONES INTO THE UNITED STATES 1912–1915

	1912.	1913.	1914.	1915.
Diamonds, uncut, free	$9,863,770	$11,616,286	....	....
Diamonds, uncut, dut	....	956,576	$2,976,227	7,047,945
Diamonds, cut but not set, dut	22,876,042	24,886,133	12,022,146	13,140,548
Bort, dut	....	....	....	26,752
Pearls and parts of, not strung or set, dut	5,139,406	5,004,489	2,142,221	4,309,837
Other precious stones, uncut, free	115,812	47,716	....	....
Other precious stones, uncut, dut	....	9,459	32,596	76,371
Other precious and semi-precious stones, cut, but not set, dut	3,342,219	2,740,804	1,630,715	1,021,221
Imitation precious stones, dut	1,215,471	1,299,145	961,082	898,656
Totals	$42,552,720	$46,560,608	$19,764,987	$26,521,330

The reduction of imports of diamonds and precious stones to Canada owing to the war is exhibited by a report of the Canadian Department of Trade and Commerce, giving in comparison the figures for April–December, 1914, and April–December, 1915. The value and sources of these imports are as follows:

	Source.	Apr.–Dec., 1914.	Apr.–Dec., 1915.
Diamonds, unset	United Kingdom	$961,128	$371,641
	United States	29,940	6,634
	Belgium	194,242	....
	France	48,052	3,345
	Germany	704	....
	Netherlands	151,948	78,866
	Other countries	12,921	5,509
	Total	$1,398,935	$465,995
Precious stones and imitations thereof, and pearls	United Kingdom	$52,719	$33,883
	United States	22,347	33,746
	France	21,868	10,916
	Germany	10,206	....
	Other countries	11,880	5,104
	Total	$119,020	$83,649
	Grand total	$1,517,955	$549,644

Four months of the first period preceded the war. It will be noted that while all the other figures show marked decreases, the importation from the United States, under the heading precious stones other than diamonds, imitation stones and pearls, shows an increase of 50 per cent., probably due to an increase in the value of precious and semi-precious stones exported to Canada from this country.

Precious Stones of Madagascar.

To encourage direct trade in gem material between the United States and Madagascar, the Governor General of that island has supplied the United States Consulate at Tamatave with sample-specimens of some of the leading gems found there, such as pink beryls (morganite), cordierites, amethysts, spessartite garnets, blue beryls and kunzites. Highly prized are the blue beryls of a sky-blue hue from Tongafeno, Fefena, and neighboring places; the transparent tourmalines from Sahantany are also very fine, the colors comprising pigeon-blood red, violet, rose-pink, green, blue, brown and yellow; some of these yellow tourmalines are of a brilliant gold-color. North of Ankaratra are rich deposits of rubies and sapphires.

Diamonds

South Africa.—The effect of the war on the diamond production of the South African Union is evidenced by the official returns for the 6 months ended June 30, 1915. The production of the mines for this period is infinitesimal compared with previous years, as the following figures show:

Transvaal,	383.00 carats,	value £ 117
Cape,	565.50 carats,	value £ 2,146

Alluvial and other diggings produced, roughly, one-half of the diamonds they did in the same period a year ago, as follows:

Transvaal,	13,304.63 carats,	value £47,700
Cape,	23,526.50 carats,	value £82,355
Free State,	424.69 carats,	value £ 2,144

The total production of the mines and at the diggings during the half year was:

Mines,	948.50 carats,	value £ 2,263
Alluvial,	37,255.82 carats,	value £132,199

The production for 1914 at the mines of the Union was 2,653,089.70 carats, value £4,906,342, while the output of the diggings was 143,924.62 carats, value £576,729.

Official returns from the Mines Department place the total diamond production in the Union of South Africa for 1915 at 103,385.7 carats having a value of £399,810. The tremendous falling off due to the cessation of all work in the great mines is shown by the following figures giving the value of the diamonds produced from 1912 to 1915; in the year 1914 productive work was stopped at the beginning of August:

1912	£ 10,061489
1913	11,389,807
1914	5,483,071
1915	399,810

In the past year the Transvaal alluvial fields furnished 35,502 carats, valued at £128,067, almost the whole supply coming from the Klerksdorp Bloemhof fields. Of the 66,471 carats (worth £266,198), from Cape Province, the contribution of Barkley West was 54,140 carats (worth £224,810). In the Orange Free State only 1240 carats of diamonds were mined, mostly from the Boshof district.[1]

The Twenty-Seventh Annual Report of the De Beers Consolidated Mines, Ltd., for the year ending June 30, 1915, covers a period almost entirely within the duration of the war, mining having been done for only a few days over 1 month, as all work was stopped Aug. 8, 1914. Hence the income of the company was greatly reduced, the diamonds sold, less decrease in stocks at cost, amounting to but £574,398 as against £5,123,335, plus the increase of stocks taken at cost, for the previous year. The interest on dividends amounted to £142,003 and other revenue to £19,048 giving total receipts of £735,449. The expenditures for mining operations (July 1 to Aug. 8) were £204,219; expenditures on farms and electric railway, on debentures and capital of leased companies, as well as for sinking fund of debentures, totaled £413,968; this makes £618,187 for normal expenses, which were more than covered by the receipts. The expenditure consequent on the war, however, reached the large sum of £625,860 of which nearly £250,247 represented the writing off of the depreciation of reserve, special investments, etc., and £375,613 expenses directly connected with the war.

A large part of this amount, £248,294, went to provide work for employees after the diamond-mining operations had ceased, to which must be added £17,933 for gratuities to employees who had resigned. To those who had gone on active service, whether in South Africa or overseas, half of their ordinary pay was given, with a minimum of 7s. 6d. per day. The military pay was deducted from this allowance in South Africa, while for those in service across the seas it was left to the volunteer. Due to these and other heavy charges entailed by the war, the excess of expenditures over revenue was £258,350, to which was added the security depreciation of £250,247, making a total deficit of £508,597 on the years' operations.

[1] *So. Afr. Min. Jour.*, Mar. 4, 1916, p. 615.

The value of diamonds unsold on June 30, 1915, amounted to £848,428 against £919,320 for June 30, 1914. In each case the value is based upon the cost of production. In view of the present excess of demand over supply, owing to the entire cessation of production for a long period and to the restricted working where operations have been renewed, the selling price of the stock is considerably higher than the book valuation.

As mining operations were carried on for about 5 weeks of the fiscal year 1914–1915, the figures for that brief time can be subjoined here, with those for 1913–1914 and 1914–1915:

DE BEERS AND KIMBERLEY MINES

	Loads of Blue Ground Hoisted.	Loads of Blue Ground Washed.	Carats of Diamonds Found.	Selling Value per Carat.
1913	351,347	419,881	120,514¾	67s. 3.74d.
1914	None	75,815	27,346½	80s. 10.21d.
1915	None	None	None	None
WESSELTON MINE				
1913	2,226,157	2,143,232	576,458	51s. 2.88d.
1914	2,373,522	2,083,352	593,305	45s. 7.62d.
1915 (June 30–Aug. 8, 1914)	217,483	219,276	56,359¼	37s. 7.13d.
BULTFONTEIN MINE				
1913	2,313,477	2,096,378	874,430¼	45s. 9.29d.
1914	2,279,838	2,069,552	785,510¾	40s. 10.47d.
1915 (June 30–Aug. 8, 1914)	256,950	214,021	76,084	33s. 6.86d.
DUTOITSPAN MINE				
1913	2,491,235	2,330,234	540,033	93s. 0.45d.
1914	2,513,469	2,412,679	497,459	84s. 0.9d.
1915 (June 30–Aug. 8, 1914)	264,039	260,024	55,609¾	....
GRAND TOTALS FOR ALL MINES				
1913	7,382,216	6,989,725	2,111,436	....
1914	7,166,829	6,641,398	1,903,621¼	....
1915 (June 30–Aug. 8, 1914)	738,472	693,321	188,053	....

Although averages based upon a few weeks mining fall far short of being so significant as averages for an entire year, it may still be of some interest to see the indications in this direction at the outset of the sadly interrupted year 1914–1915.

WESSELTON MINE

	Cost of Production per Load.	Value per Load.	Profit per Load.
1913	4s. 4.45d.	13s. 10.02d.	9s. 5.57d.
1914	4s. 7.28d.	12s. 9.33d.	8s. 2.05d.
1915 (June 30–Aug. 8, 1914)	4s. 8.6d.	9s. 9.29d.	5s. 0.69d.

BULTFONTEIN MINE

1913	4s. 1.28d.	19s. 2.79d.	15s. 1.42d.
1914	4s. 4.29d.	15s. 6.38d.	11s. 2.09d.
1915 (June 30–Aug. 8, 1914)	4s. 2.4d.	11s. 9d.	7s. 6.6d.

DUTOITSPAN MINE

1913	4s. 2.09d.	21s. 4.78d.	17s. 2.69d.
1914	4s. 1.49d.	17s. 7.87d.	13s. 6.38d.
1915 (June 30–Aug. 8, 1914)	4s. 5.2d.	13s. 8.45d.	9s. 3.25d.

While none of the shafts was deepened during the year, a considerable amount of tunneling and other development work was done on the Wesselton, Bultfontein and Dutoitspan mines, as follows:

	Wesselton.	Bultfontein.	Dutoitspan.
Tunnels driven in rock	1,237 ft.	1,150 ft.	1,563 ft.
Tunnels driven in blue ground	5,165 ft.	2,327 ft.	4,296 ft.
Passes sunk in rock	20 ft.	53 ft.	10 ft.
Passes sunk in blue ground	245 ft.	30 ft.	279 ft.
Timbering tunnels	285 ft.	421 ft.	....
Prospect shaft sunk in rock	....	....	50 ft.
Excavations (rock)	40,100 cu. ft.	23 cu. ft.	....

The Jagersfontein diamond mine, of which the De Beers company has a controlling interest, was worked for only 4 months of the last financial year. The cessation of operations during the remaining 8 months, while many of the expenses for maintenance still went on, entailed a deficit of £58,879 in the year's operations. The company had in its service 78 white employees at the outbreak of the war, and had paid £217,301 for wages during the year ended June 30, 1914. The greater part of these workers had to be dismissed when mining was suspended. A large number of them, as many as 450, joined the Kimberley regiments, and served in the campaign in German Southwest Africa; of those in active service, four were killed and seven wounded. The dependents of the white employees have not been neglected, 1517 persons having been rationed daily. A monthly expenditure of £6000 has been necessitated for this purpose and for wages to those still employed at the mines.

The thirteenth annual report of the Premier mine, covering the year ended Oct. 31, 1915, makes a somewhat better showing than might have been expected. Although mining operations were entirely suspended, the marketing of a portion of the diamonds in stock, amounting to £358,775 at its entered value, but to £382,215 at the higher market prices realized, furnished a balance of £340,109 for expenditure and revenue amount, after deducting £40,858 for administrative expenses and £1248 for depreciation of investments. A further deduction of £4477 for general equipment left £335,632 as net profits; 60 per cent. of this, or £201,379, went to the Union of South Africa, 40 per cent., or £134,253, remaining for shareholder's appropriation account. This was in turn chargeable with £30,740 for British and South African income tax, and with a retransfer of £47,096 to trading and emergency funds, leaving a balance of £54,626 after partly offsetting a previous debtor balance of £13,244 by sundry revenue amounting to £11,454. Since the close of the report, a preference dividend has been paid for the period from May 1 to Oct. 31, 1914, thus leaving only a single year's arrears on these shares.

As in the case of the De Beers' company, the Premier has paid allowances to the families of the men in its employ who went to the front, and has assisted those who were unable to find occupation elsewhere. Both the men still in employment, and those who left when the mine shut down, are permitted, with their families, to occupy the houses on the company's property, and are supplied with electric light, water, etc., free of charge. The fact that there are from 300 to 400 children in the school indicates how largely these privileges have been utilized.

All pumping having ceased since the shutdown, there has been a great accumulation of water in the mine, estimated at 150,000,000 gal. The quantity is much greater than had been expected, owing to the exceedingly heavy rainfall. However, all material which might be damaged, if submerged, was brought up to the 260-ft. level, and a resumption of pumping on a small scale, which was decided on, will prevent the water from rising higher than its present level.

The 54 men still employed have been able to do much useful work in the maintenance of the machinery and plant, certain repairs having been attended to which could not have been accomplished easily except during a total stoppage of operations. To provide a plentiful supply of timber for mining purposes, a plantation of 20,000 gum trees has been established on the farm Lousbaken. The amount expended for wages and for allowances to dependants of those in active service was £20,500.

The managers of the Premier mine seem to have some justification in protesting against the imposition of an income tax on the mining profits, as the Government already receives 60 per cent. of the net profits, three-fifths of the mine being regarded as owned by the Government. In reality this arrangement is held to constitute a contract guaranteeing the remaining 40 per cent. of net profits to the operating company. Hence the imposition of a 10 per cent. income tax is looked upon as a violation of the rights conceded. This tax was levied in 1914, and has of course been paid. Whatever the merits of the company's contention, relief is little likely to be afforded during the present war time at least.

The Orange Free State and Transvaal Mines, Ltd., organized about 20 years ago, has just gone into voluntary liquidation, the indebtedness being only £1600. The chief assets are 664 acres of freehold land in the Kaarvallei Farm, and the adjoining Dirksburg Farm of 2389 acres. The great depression of this kind of property in South Africa at present is stated to make it unlikely that other than a small dividend can be declared.[1] The capital is £550,000 in £1 shares.

The New Vaal River Diamond Co. reports a diamond output of 27,980 carats for 1914. The amount realized was £136, 923 or £4,18s., 2½d., per carat. For the first 6 months of the year, prior to the war, the average price for these high-grade alluvial stones was £5, 5s., 6d., per carat, a falling off of 5 per cent. from the previous year's showing, but the sharp break after the beginning of the war reduced the general average to the above-noted figure. Large reserve areas of alluvial deposits belonging to the company remain untouched, the output for 1914 coming almost exclusively from areas already worked.[2]

Rhodesia.—In the Bambesi and Shangani valleys, southern Rhodesia, a half dozen fissures of Kimberlite have been found, the prospectors being guided by the ilmenite and garnet in streams and soil. An obstacle to the operations was the fact that the Kimberlite veins lie beneath a deep covering of soil and bush. The district wherein these Kimberlite fissures appear, extends some 30 miles in a northeasterly direction from near Lochard to a point between the Shangani River and its tributary, the Vungu. The average distance from Bulawayo is about 60 miles; from Guelo, 40 miles. In two of the Kimberlite deposits small diamonds have been found, but not in sufficient quantity to make working profitable. This may, however, prove to be the case in some other of the already known veins or else in other pipes or fissures yet to be discovered here. Nearer to Guelo are the diamantiferous beds in the Somabula forest, which have been traced by Mr. Zeally for about 70 miles in an northeasterly direction from Willoughby's Halt. These beds are of two classes: in the lower beds the gravel is well rounded, while in the other ones the pebbles are less rolled. Both series rest upon a granite floor; in the lower series, evidently deposited by some ancient river, appear, besides diamonds, a number of gem-stones, such as chrysoberyl and white

[1] *So. Afr. Min. Jour.*, Aug. 14, 1915, p. 564.
[2] *So. Afr. Min. Jour.*, May 22, 1915, p. 273.

and blue topaz. They are nearly always at the bottom of the beds, where they rest upon the granite. The presence of dark water-worn crystals of staurolite, or "blacks" as they are locally called, are the best indicators of the diamond-bearing beds. Some 30 or 40 diggers worked on these deposits in 1914. The conditions for working on a large scale seem to be unfavorable, because of the depth at which the beds usually lie, and the poor supply of water. However, richer leads may eventually be found.[1]

Brazil.—For the first time in the history of Brazilian diamond mining, diamonds are now reported to have been found there in the matrix, rendering it possible to carry on regular diamond mining operations, instead of mere washing. This discovery is stated to have been made by Dr. Eberhard Rimann, who has devoted special study for many years to the South African diamond mines, and was called in 1912 to the National Geological Institute in Rio de Janeiro as chief mineralogist and petrographer.

The Brazilian state of Bahia exported to the United States, in 1915, rough diamonds to the weight of 11,803 carats, and 3714 carats of carbonados. The mining operations in this State are mainly carried on by small individual undertakings. Most of the diamonds were of ½ carat or less, and the average price at which they were invoiced was about $18 per carat. The carbonados sold at a higher figure. These "miners' diamonds," as they are sometimes called, because of their employment in drills, etc., were invoiced at the United States consulate in Bahia as follows: ¼-carat stones, $12 to $14; ½-carat stones, $16 to $20; ¾-carat, $20 to $23; 1-carat, $25; 2-carat and upward, $35.[2]

Brazil (By Benjamin L. Miller and Joseph T. Singewald, Jr.).—Although diamond mining, or diamond washing, has been carried on continuously in the Brazilian fields since 1721 they are still far from exhaustion and each year the yield is sufficient to support several large and prosperous communities. Unquestionably the largest and richest pockets, such as pot-holes in the beds of the streams, have been worked out, yet the area over which diamond-bearing materials is spread is so extensive that the diamond industry of the country will continue for many years to come.

Minas Geraes, Bahia, Goyaz, and Matto Grosso, named in the order of their importance, are the States where diamonds are found. The manner of occurrence in all places is the same and the original rock matrix remains conjectural. It is believed, however, that they were originally contained in some igneous rock, probably a peridotite, and on its de-

[1] *Min. Mag.*, July, 1915, p. 47.
[2] Consul Robert Frazer, Jr., of Bahia, in *Comm. Repts.*, Feb. 18, 1916, p. 675.

composition and disintegration, the diamonds were released and transported by streams to inland lakes, seas, or the ocean, where they were deposited with other materials, mainly grains and pebbles of sand. Later these loose particles were cemented to form sandstones or conglomerates. In a few places, diamonds have been found in these firm quartzose rock, but not in workable quantities. When the rocks have disintegrated and the particles again concentrated by running water the diamonds are now found. First the stream gravels were worked but as they have been worked over, in some cases, several times, they now yield few diamonds and the higher-lying terrace gravels furnish most of the stones.

At the Sopa mine in the Diamantina district an English company tried to work the ground on an extensive scale by means of steam shovels but without success, although £250,000 was spent in the project, and in 1915 the expensive machinery was sold at great sacrifice. The irregularity of the diamond-bearing earth is such that the shovel method is the only practicable one. The concentrating work is done in part by means of jigs and in part by the batea.

The lack of sufficient water to wash the gravels during the dry season greatly reduces the output of the Brazilian fields. The annual production of the country can only be guessed as the Government tax on the stones causes many of the producers to conceal their finds and to dispose of them secretly. Many of the stones are cut in Diamantina although the work is usually so poorly done that some are recut in America or Europe.

Two projects have been started to work the diamond and gold placers along the Jequitinhonha River but so far without success. In 1915 another company, financed by American capital, was carrying on investigations in another part of the river with the intention of later constructing a dredge if the results of the prospect work justify the undertaking. One of the dredge enterprises was a failure on account of the later discovery that most of the ground had already been worked, probably 100 or 150 years ago by diverting the stream by means of dams, and in another case the dredge was torn from its moorings during a flood and lost. At present, therefore, it has not been proved whether dredging for diamonds and gold in the large streams can be carried on with profit or not. If dredging proves successful no doubt the output of Brazilian diamonds will materially increase during the next few years as there is believed to be considerable virgin ground along several of the large streams, especially the Jequitinhonha River.

Canada.—The list of the mineral localities of Canada published by Dr. Robert A. A. Johnston, Mineralogist-in-Charge of the Geological Survey of Canada, and Curator of the Royal Victoria Museum of Ottawa is a valuable aid to anyone interested in the minerals of the Great

Dominion.[1] Of especial interest in this report are the occurrences of microscopic diamonds, of tourmalines, etc. While the brief indication of type and locality cover a wide field, somewhat less attention has been paid to Canadian gem-stones. A list of these was prepared some time since by the present writer.[2]

Of the localities where microscopic diamonds were found in connection with chromite, or chrompicotite occurring in dunite, two are in British Columbia, in the Clinton mining division, in the chrompicotite of Scottie Creek, Bonaparte River, and in the Similkameen mining division, with the chromite of Olivine Mountain. They have also been noted in chromite deposits of Rheaume township, Timiskaming district, Ont., and in the chromite of Black Lake, Megantic County, Que.

Practically no work has been carried on during the year in the region where diamonds have been found in Pike Co., Arkansas. The watchman at the Arkansas Diamond Co., mines found in all 32 stones—white, yellowish and brown—one of which, weighing 0.32 carat, another, weighing 1.22 carat, and a third, weighing 2.50 carats, were transparent and perfect. The total weight was 17.9 carats.[3]

The manifold resources of Arkansas are very fully suggested by a recent bibliography of the literature on this subject prepared by J. C, Branner, former State Geologist of Arkansas, as an appendix to the interesting description of Arkansas slates by A. H. Purdue, Professor of Geology in the University of Arkansas, and ex-officio State Geologist.[4] The bibliography lists eight contributions of the present writer to the study of Arkansas minerals, noteworthy among these being the description of the interesting diamond deposits in this state.[5]

Agate

Agates have been so freely used for ornamental purposes, and are in such constant demand, that the comprehensive monograph on this variety

[1] List of Canadian Mineral Occurrences, Canada, Dept. of Mines, Geological Survey, *Memoir* 74, No. 61 of Geological Series, Ottawa, 1915, iii + 275 + viii, pp. 80.

[2] George F. Kunz, "Gems and Decorative Stones in Canada and British America," Report (pp. 1–16), from *Report of Dept. of Mineral Statistics*, Geological Survey of Canada, 1887, Ottawa, 1887, with references to the literature.

[3] The following important articles on the subject must be noted here: John T. Fuller, "Diamond Mine in Pike County, Arkansas," *Engineering and Mining Journal, Vol.* LXXXVII, pp. 152, 155, Jan. 16, 1909; idem. pp. 616, 617, Mar. 20, 1909; John C. Branner, "Some Facts and Corrections Regarding the Diamond Region of Arkansas," *Engineering and Mining Journal*, Vol. LXXXVII, pp. 371, 372, Feb. 13, 1909; P. F. Schneider, "A Preliminary Report on the Arkansas Diamond Field," *Bureau of Mines, Manufactures and Agriculture*, 16 pp., Little Rock, 1907. On the use of diamond drills there is: John T. Fuller and Sam C. Sanford, "Record for Deep Well Drilling" for 1905, Bulletin 298, *U. S. Geol. Surv.*, Arkansas Wells, pp. 34-39, Washington, 1906.

[4] A. H. Purdue, "The Slates of Arkansas;" J. C. Branner, "Bibliography of the Geology of Arkansas," The Geological Survey of Arkansas, 1909 (Little Rock, 1909), xii + 170 pp. 7 maps and plates.

[5] George F. Kunz, "Diamonds in the United States, "*Mineral Industry*, for 1907, Vol. XVI, pp. 797-803, New York, 1908;

George F. Kunz and Henry S. Washingtin, "Note on the Forms of Arkansas Diamonds," *Am. Journ. Sci.*, Vol. CLXXIV, pp. 275, 276, New Haven, Sept, 1907; and the same authors, "Diamonds in Arkansas," *Bi-Monthly Bulletin of the American Institute of Mining Engineers*, No. 20, pp. 187-194, New York, 1908. *Engineering and Mining Journal*, Aug. 10, 1907, Vol. LXXXIV, p. 270.

of decorative stone by Dr. Raphael Ed. Liesegang,[1] is important both for mineralogists and jewellers. In addition to a clear and attractive presentation of the main facts as to the agate, its growth, composition and varieties, this writer devotes a section to the description of the many and various modes of coloring agates artificially, noting that already in Pliny's time the practicability of such processes was admitted. The earliest known process was the imparting of a black hue by means of honey, and then dipping the agate into sulphuric acid, carbonizing the sugar. The production of a ruddy color by the application of great heat was practised as early as 1813 in Oberstein, Germany, and in 1845 an artificial green was reported. Since then a great variety of colors and shades have been secured, a full account of the methods employed being given in this monograph.

Emerald

The emerald mines of Colombia—the so-called emerald mines of Peru—in other words, the only mines from which emeralds have been obtained for the past three centuries and from which the wonderful emeralds were secured by the Spaniards in the conquest of Peru, have been examined from time to time in a desultory manner. It is fortunate that during the year 1915 a careful scientific survey was made of these deposits by Dr. Joseph E. Pogue, whose conclusions are of the greatest interest and value.[2] They are as follows:

"The Muzo emerald deposits, which are the most important in the world, are situated in the western foothills of the eastern branch of the Colombian Andes, distant about 96 km. in a direct northwesterly line from Bogotá. These, in common with two neighboring deposits, had long been worked by the natives when the Spaniards first set foot in the New World, and formed the principal, if not the sole, source of the emerald among the Chibchas, Incas, and probably also the Aztecs. Following the Conquest, the Muzo deposits have been worked up to the present, furnishing many of the world's finest emeralds.

"The emeralds occur almost exclusively in calcite veins that traverse a black, carbonaceous, rather intensely folded formation consisting of thin-bedded shale and limestone of Cretaceous age. This emerald formation is overthrust onto steeply dipping strata, barren of emeralds, composed of heavier beds of carbonaceous limestone intercalated with black shale; and the thrust-plane is strongly mineralized. The emerald is closely associated with the following minerals which form its gangue: calcite, dolomite, pyrite, parisite, quartz, barite, fluorite, and apatite.

[1] Raphael Ed. Liesegang, "Die Achate," Dresden and Leipzig, 1915, iv + 118 [+ 4], pp., 60 text cuts, 80.

[2] Joseph E. Pogue, "The Emerald Deposits of Muzo, Colombia," *Bull. Amer. Inst. Min. Eng.*, May, 1916.

A few pegmatite veins occur near the emerald-bearing calcite veins, and the topmost part of the formation underlying the emerald-bearing beds is strongly albitized.

"The mineral association, the presence of pegmatites and albite rock, and the structural conditions form practically conclusive evidence that the emerald is one effect of a period of mineralization growing out of the intrusion of a body of igneous rock, although the latter is in no place exposed. It may be inferred further that the emerald was deposited under pneumatolitic conditions, at a temperature below 575°."

The deposits here first became known to the Spaniards in 1537, when some Chibcha Indians of this district gave nine emeralds, as gift or tribute, to Gonzalo Jimenez de Quesada, founder of the city of Bogotá. However, it was not until 1558 that mining operations under Spanish direction were instituted. The deposits at the site of the Muzo mines of to-day were not found by the Spaniards until 1594 and for some years were actively exploited. The Peruvian emeralds appropriated by the Spaniards in the sixteenth century were almost certainly derived from these Muzo mines, or at least from deposits in this region. In the succeeding centuries work has been carried on more or less actively at times, with long intervals of merely desultory mining. Since the abrogation in 1909 of the contract between the Colombian Emerald Mining Co., Ltd., an English company controlled by South African diamond interests, and the resumption of control by the Colombian Government, little or no work has been done except in the way of maintenance. More than 150 emerald localities are estimated to have been found in the region, all in Dept. Boyaca. In the Province of Velez, Dept. Santander, at a point some 37 miles distant from Muzo, in a northeasterly direction, in the line of the emerald formation, a locality has recently been reported.

Within the past year a number of most interesting crystals of pale emerald have been found in the province of Minas Geraes, some of them transparent, but in many respects resembling those from Alexander County, N. C. and from Emeraldville, New South Wales. They are usually a perfect pale green, very brilliant. Many of the stones have been cut, their weight ranging from one to 40 or 50 carats.

Remarkable crystals of deep blue beryl have also been brought during the year from Minas Geraes. Some of them attained a diameter of 5 cm. and measured from 8 to 12 cm. in length. They were hexagonal prisms, the lowest faces being cylindrohedral.

Jade

The Jadeite of Upper Burma comes in part from solid serpentine rock in the Kachin Hills about 120 miles from Mogoung, and in part from the bed and banks of the river Uru, where it occurs as rolled pebbles, on the stretch extending some 15 or 20 miles from Mamon up to Fort Sanka. In 1806 a jade station was established by the Burmese Government at Mogoung, the height of its prosperity being in the decade from 1830 to 1840, at which time as many as 1400 persons are said to have found employment there. Political complications and disturbances have frequently interfered with this industry, but since 1889 it has been efficiently protected by the British Government. The river deposits are exploited by means of divers, and the total output of a quarter of the territory within a radius of 500 yd. from Mamon is put at $2,000,000. The principal market for Burma jade is China, only a small quantity being exported to Europe; a certain amount is retained in Burma. The prospects for increasing the supply are pronounced to be excellent.[1]

Labradorite

There is recorded a new find of transparent, pale yellow labradorite in Millard County, Utah,[2] occurring in scoria, which is of interest as a gem although it is not of great hardness. This is almost identical with the occurrence in the locality in the Altar Mountains, Ariz., described in 1914, which was the first reported instance of a transparent labradorite.

Opal

The opal deposits in Humboldt County, Nev., are in the southwestern extension of the region known as the "Idaho Lava Beds," which traverses southern Oregon and northern Nevada. The first specimen of gem-quality was found in 1912, by a miner named "Deb" Rupp, on Virgin Creek, at a point 200 miles south of the Nevada-Oregon line. The greater number of the opals come from a bed having a greenish tint due to the reduction of iron oxides by the organic remains in the volcanic ashes, which are believed to have been deposited during the Miocene period, as indicated by the bones of animals of this age found in the ashes. These opals present a great variety of colors—black, red, green, indigo, orange, etc.; the specimens ranging in size from very small pieces to those weighing a pound or more. They are of excellent quality.[3]

An opal field has been reported from South Australia in the region west of Nuna Creek, the specimens (said to be of "noble opal") coming from the so-called desert sandstone, a formation of upper cretaceous age. The fire, while principally red, shows blue and green flashes also, the opalescence being mainly confined to fissures in the mass of the stone.

[1] Maxwell K. Moorehead, Ranjoon, India. *Daily Cons. Tr. Rept.*
[2] Communicated by George L. English.
[3] J. Carl Bray, "Opal Field in Nevada," *Min. Jour.*, Dec. 11, 1915, p. 4.

The specimens have considerable similarity with those from the white cliff region of New South Wales.[1]

Pearls

In France, at the present time, as a war measure, the importation of precious stones was prohibited May 16, 1916; pearls, however, are still admitted. The object of the temporary restriction is of course to limit the supply of luxuries, but the exception accorded to pearls, which may seem illogical, is due to the fact that Paris has become a great distributing center for these beautiful gems, so that a large export trade in them partly offsets the imports and the operations of the pearl market thus become rather a factor of economic gain than one of economic loss.

A notable feature of the active pearl market in New York is the steady growth of direct importations from India. The great Indian distributing center, Bombay, used to trade almost exclusively with Paris and London, but as, owing to the economic pressure of the war, the demand from these markets has fallen off considerably, the pearl shipments are now often made directly to New York, and certain of the Bombay merchants have been enterprising enough to send Indian representatives to that city so as to stimulate direct trade with India. The present New York imports from that land are greater than at any previous time.

Sapphire

Sapphire never enjoyed a more royal favor than it did during the past year and still continues to do. At the same time, the increased price has brought out many old gems of great beauty, a usual result when higher prices can be realized in the market. The Montana mines, which have yielded such splendid material in the past, are now being worked to their full limit, succeeding to the comparatively restricted product of 1914. The lion's share of the value of American precious stones produced has, for the past few years, belonged indisputably to the sapphire.

As the market for the sapphires from Queensland, Australia, was formerly in the hands of the Germans, the product having been sent to the gem-cutting establishment at Idar-on-the-Nahe, the war put a stop to all dealings. Application by the Queensland Mines Department to the Agent-General in London as to the possibility of doing business in the London market, brought little encouragement, as the Australians were told that not only was the demand poor but that the London dealers were disinclined to purchase Australian sapphires since they believed that this

[1] *Min. Jour.*, May 1, 1915.

trade would revert to the Germans after the war. They also blamed the Australian mine owners for failing to support the sapphire market by a restriction of output.[1]

The sapphire production of Queensland for 1913 had a value of £43,222 ($216,000), the total output up to the end of the year being £269,494 ($1,345,000.)

The sapphire mines of Montana were principally operated by The New Mine Sapphire Syndicate of London. No mining operations were carried on in the year 1915 other than the process of washing the various dumps. The cuttable sapphires thus obtained in 1915 amounted to 36,863 carats and the culls, as the uncuttable material is called, which has no other use except for watch jewels and for industrial purposes, amounted to 506,700 carats. The sapphire is in greater vogue than ever, with the result that the material was sold to good advantage.

A specimen of gem-sapphire furnishing a cut stone weighing 1⅜ carats was discovered in 1912 in gravel on the shore of Lake Okoboji, Dickinson County, Iowa. This was a water worn pebble of cornflower blue, and is assumed to have been brought down by glacial action from some undetermined region far distant from the place where it was found.[2]

Turquoise

The most important American contribution to the description and history of gem-stones during the year 1915, was the comprehensive and able monograph published by Dr. Joseph E. Pogue on the turquoise.[3] The description and illustration of the use of turquoise by the pre-Columbian Indians of America give full and trustworthy data on this most interesting subject. The publication not only does great credit to the writer, but also to our National Academy of Sciences under the auspices of which it was issued.

An attempt has been made to mine a turquoise deposit in Lower California on a high plateau called El Aguajito, between Rosario and the former mission of San Fernando. The undertaking was given the name, Mina de la Turquesa, but only material without commercial value was extracted. Possibly had the mining been carried down to a greater depth, turquoise of better quality might have been secured. The turquoise occurs in fractures traversing a dioritic rock. The material seems to have suffered disintegration from disturbances posterior to the period of its deposit, so that larger pieces can scarcely be found.

[1] *Min. Jour.*, May 15, 1915.

[2] Douglas B. Sterrett, "Gems and Precious Stones in 1914," Washington, 1915, p. 326; U. S. Geol., Surv.

[3] Joseph E. Pogue, "The Turquoise: A Study of its History, Mineralogy, Geology, Ethnology, Archæology, Mythology, Folklore, and Technology," National Academy of Sciences, Vol. **12**, Pt. II 3d *Memoir*, Washington, 1915, 206 pp. incl. illust., 22 pl. (1 col.), col. front. 4°.

QUICKSILVER

By Clifford G. Dennis

Production of quicksilver in 1915 shows an increase of 27 per cent. over that of 1914, 21,033 flasks of 75 lb. each having been produced in 1915 and 16,548 in 1916. Of the 1915 production, 3370 flasks were exported against an importation of 5636 flasks showing a local consumption of approximately 23,299 flasks.

PRICE, PRODUCTION, AND TOTAL VALUE OF QUICKSILVER IN UNITED STATES FROM 1850 TO 1915 INCL.

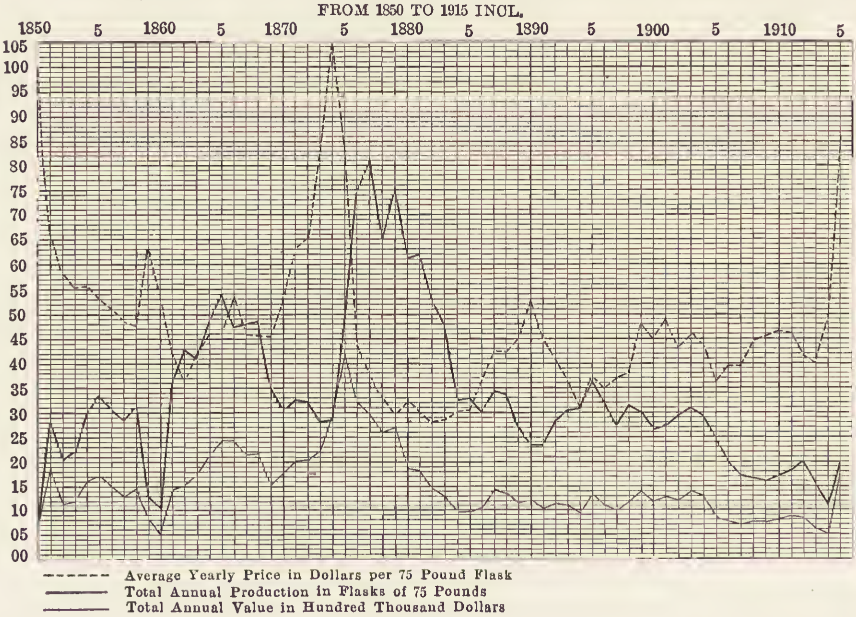


Fig. 1.

The value of the 1915 production was approximately 117 per cent. greater than that of 1914, the 1915 production being valued at $1,768,225 and that of 1914 at $811,680. This is the greatest value for any one year's production noted since 1881, when a production of 60,851 flasks was valued at $1,815,200 or an average of $29.83 per flask, while the 1915 production was valued at $82.50 per flask.

The above chart shows graphically the average yearly price per flask, the annual production in flasks and the total annual value in hundred thousand dollars from 1850 to 1915 inclusive.

Of the above 21,033 flasks produced it is estimated that California produced approximately 14,000 flasks and Texas and Nevada produced the balance of 7033 flasks.

The following chart shows the average weekly quotations and the average price per flask from Jan. 1 to any date of 1915.

The next chart shows the approximate quicksilver movements from July, 1914, to December, 1915, inclusive. This chart has been drawn to

AVERAGE WEEKLY QUICKSILVER QUOTATIONS FOR 1915

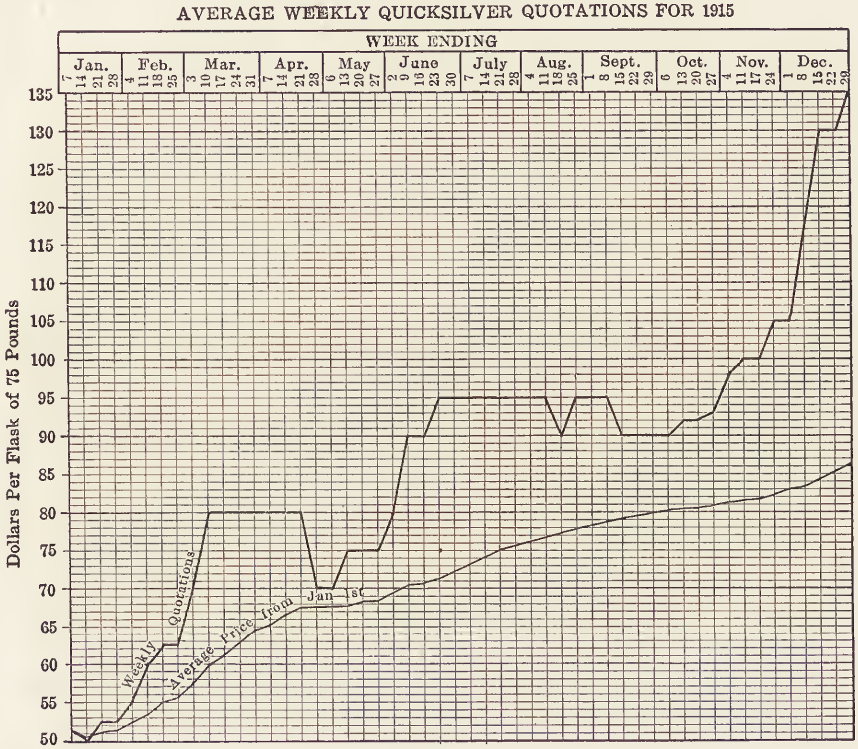
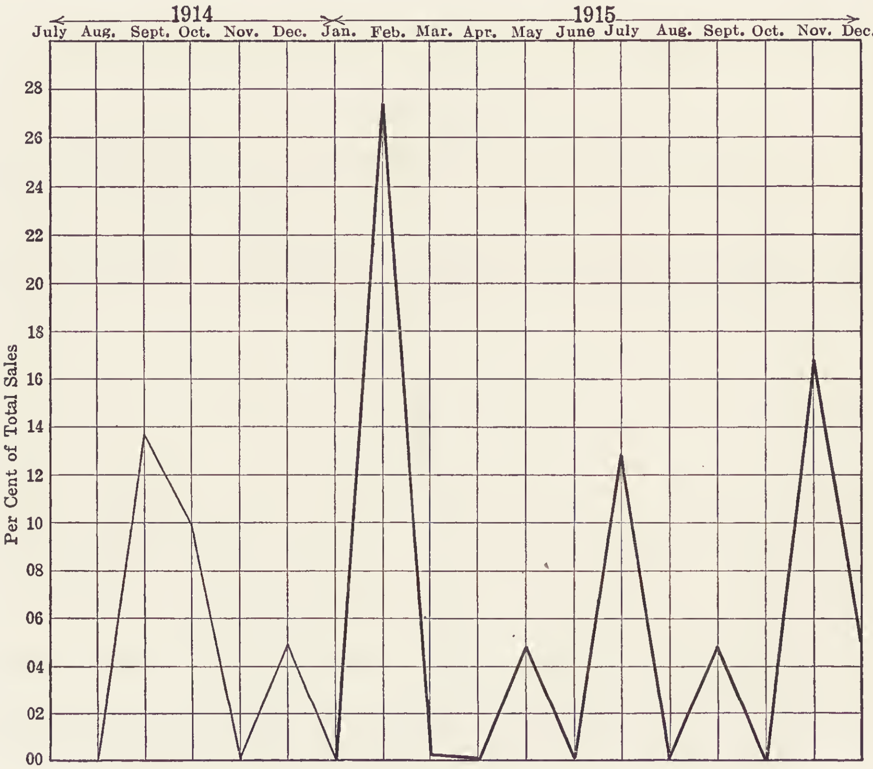


FIG. 2.

represent the sales by the producers as closely as it was possible to determine. It was drawn for the 18 months to show the successive small movements followed by larger movements and in passing it might be well to note that the small movements almost invariably represent sales to speculators while the larger sales represent sales to actual consumer.

In December, 1914, the price of the metal was around $50 per flask and the majority of the sales were to speculators. In February, 1915, there was a real demand for the metal and the sales amounted to approximately 27½ per cent. of the years sales. The price during this period advanced from $50 to $80. During March and April there were practically no movements and the price dropped to $70 the last week of April. In May there was a light demand by speculators and the price advanced to $75. There was very little movement in June, although the



Quicksilver Movements as shown by Sales Records July 1914 to Dec. 1915 Incl.

FIG. 3.

price advanced to $95. In July there was a brisk demand by explosive manufacturers although the price did not advance above $95. In August the market was very slow and a drop in price to $90 resulted. It returned to $95 however, in September and there was some buying by speculators. The price again dropped to $90 before the end of September, where it remained until the second week in October when the price started to climb, reaching $105 the latter part of November, when producers practically depleted their stocks. In December the quotations reached $135 and many sales were made from $150 to $175.

The movement chart is interesting from the producer's standpoint and for those contemplating becoming producers. It shows that quicksilver is not a commodity that can be produced and sold from day to day, or even from month to month. It is something that has to wait for a market; consequently it requires considerable capital to operate a quicksilver mine after the mine is equipped and producing.

California.—San Bonito County.—The principal producer in California was the New Ida mine situated in San Bonito County. The ore mined and reduced ran from 0.25 per cent. to 0.40 per cent. and much of it came from old workings, including old croppings left in the early history of the mine as too low-grade to pay. The production amounted to 6250 flasks.

The Alpine mine situated in San Bonito County in the New Idria district erected a 20-ton Scott-type furnace and is prepared to produce in 1916.

The Wonder and Hernandez mines in this county produced some metal in 1915 as did also the Aurora.

Santa Clara County.—The New Almaden property produced considerable metal in 1915, most of the ore coming from the El Semdor workings. Some ore also came from other mines owned by this company and a quantity of the metal was cleaned from the old dumps and furnaces.

The Guadalupe mine had a most successful year from ore taken from new workings opened by H. C. Davey. Mr. Davey exercised his option on the property during the year, taking it over from the James V. Coleman interests.

Lake County.—The Helen mine was operated during the year and after extensive furnace repairs were completed experienced a very successful year.

The Great Western and Wall Street mines produced some metal during the year and are preparing for a greater production in 1916.

Napa County.—At the Oat Hill mine concentration of the old dumps was carried on and a production from 70 to 150 flasks per month was maintained. The addition of a Neal jig to the plant had the effect of greatly increasing the capacity, at the same time making a closer and cleaner saving of concentrate and decreasing the consumption of water per ton ore treated.

The Aetna mine was re-opened and preparations made for starting the furnace. Concentration of the old dumps was successfully carried on and a satisfactory production made.

The Knoxville mine was re-opened and some metal produced.

Solano County.—The St. Johns mine was operated during the year, the ore averaging bout 0.5 per cent. A new fine-ore furnace was put in operation during the year which, with the old coarse ore furnaces, gives a combined capacity of about 40 tons per day.

The Hastings mine was re-opened during the year but no production was reported.

San Louis Obispo County.—The Oceanic mine had a most successful year, producing approximately 1400 flasks from ore mined out of the old workings. The 50-ton furnace and concentrator operated successfully and a new 50-ton furnace is contemplated for 1916.

The Cambria mine operated successfully on ore from old workings and from new mine developments.

General.—The Great Eastern, Cloverdale, and Culver Bear mines in Sonoma County were re-opened and preparations made for early productions.

The Reed mine in Yolo County is being re-opened.

The Parkfield mine in Monterey County produced some metal and is being prepared for additional production in 1916.

The Mercy mine in Fresno County produced considerable metal and is said to be in good physical condition for continuous production.

The Phoenix mine back of Livermore was put in operation and had a successful half year.

Nevada.—The Nevada Cinnibar Co. in the Ione district had a most successful year's operation. The Mercury mine also situated in this district operated during the year on low-grade ore but showed a handsome profit on the year's business.

The Ruby mine and the Adamson properties were developed to greater extent and preparations made for new furnaces during 1916.

Texas.—The only mine producing quicksilver to any extent was the Chisos situated in Brewster County. This mine had the most successful year in its history. The ore is high-grade, labor, fuel and supplies cheap and plentiful and large ore reserves in the mine. Everything points to many more successful years for this property.

Naturally a great deal of prospecting for quicksilver mines was carried on all over the country with reports of some success in Oregon, Washington, Montana, Arizona, Utah and Alaska but no production was reported from any of these new discoveries.

Foreign.—Spain continued to be the principal producer of quicksilver but owing to war conditions no information as to actual production can be ascertained. It is reasonable to assume, however, that the usual 1800 to 2000 metric tons were produced.

In Italy in the province of Siena, the Tuscan mines are being operated to their full capacity. The 1914 production amounted to 1073 metric tons. No data as to 1915 production is available; but one interesting fact noted is that the value of mercury exported to the United States jumped from $18,677 in 1913 to $85,300 in 1914.

The Idria mines in Austria are no doubt working full blast but, of course, no information as to production, etc., is available.

STATISTICS OF QUICKSILVER IN THE UNITED STATES

Year.	Production.					Exports.			Imports.	
	Calif. (a)	Texas.	Others.	Total.	Value. (f)	Flasks.	Metric Tons.	Value.	Pounds.	Value.
	Flasks.	Flasks.	Flasks.	Metric Tons.						
1901	26,720	2,932	75	1,031	$1,382,305	11,219	389	$475,609	1,441	$789
1902	29,552	5,252	....	1,208	1,515,714	13,247	459	575,099	*Nil.*	....
1903	32,094	5,029	....	1,288	1,564,734	17,575	610	719,119	*Nil.*	....
1904	28,876	5,336	700	(c)1,204	1,348,185	21,064	731	841,108	212	160
1905	24,655	5,000	1,050	1,045	1,217,652	13,460	458	497,470	2,690	1,710
1906	19,516	4,517	1,276	861	1,035,138	6,455	220	244,299	84	50
1907	(d)17,532	3,000	400	712	868,678	5,132	175	192,094	16,566	6,719
1908	(d)16,969	2,832	346	685	903,391	2,995	110	124,960	15,113	8,215
1909	16,217	4,188	810	704	941,233	6,803	231	266,243	15,968	8,203
1910	(d)18,536	3,382	500	763	1,054,991	1,923	65	91,077	667	381
1911	18,860	(g)2,396	....	732	989,254	291	10	13,995	471,944	251,386
1912	20,600	2,700	1,847	855	1,067,742	310	14	13,360	82,706	39,919
1913	15,396	(h)	4,285	670	774,054	1,140	39	43,574	171,653	75,361
1914	11,485	(h)	5,083	536	811,832	1,446	49	70,753	685,605	300,000
1915	14,000	(h)	7,033	716	1,768,225	3,370	115	225,509	421,884	282,852

(a) Reported by the California State Mining Bureau, except 1907–08–10–11. (b) Included in "Other States." (c) Estimated; the weight of the flask was changed from 76.5 lb. to 75 lb. within this year. (d) Figures collected by MINERAL INDUSTRY. (f) Computed at average price at New York. (g) With Nevada. (h) Included in other states.

RADIUM

By Robert M. Keeney

The market for radium during 1915 was very weak. This was due to the fact that the general use of radium in the United States for medical purposes has not advanced to the development in Europe. Aside from the radium produced by the National Radium Institute, which is not for sale, one producer sold some radium in Europe during the early part of the year, and one gram of radium in the fall to a recently formed institute in New York.

The most important development of the year was the highly successful operation of the plant of the National Radium Institute at Denver by the U. S. Bureau of Mines. The efficient commercial operation of this mill by the government was in striking contrast to the usual handling of business operations conducted under government auspices, and the employes of the Bureau of Mines deserve great credit for the efficient manner in which the work has been performed.

Production.—According to the U. S. Geological Survey, the output of carnotite ore in 1915 contained 23.4 tons of U_3O_8 and 6 grams of radium. The greater part of this was mined by the National Radium Institute which produced nearly 1000 tons of ore from the claim of the Crucible Steel Mining and Milling Co. in Long Park, Colo., and from low-grade material obtained 70 tons of concentrate containing 3 per cent. U_3O_8.

During the year this institute crystallized radium salts which contained 6 gm. of the element. It delivered 3.006 gm. of radium at a cost of $37,599 per gm. At the close of the year a private concern was reported to have sold 1 gm. for $120,000. Toward the end of the year the National Radium Institute was in the market as a purchaser of ore.

The Standard Chemical Co., the largest producer before the war, did no work on its claims beyond that required by law, but is said to have purchased a number of claims. It was reported in December that the company had produced a total of 14 gm. of radium (element), and that its ore averaged 1.7 per cent. U_3O_8. This company produced very little radium in 1915.

The Schlesinger Radium Co., under Dr. W. A. Schlesinger, established a plant in Denver and acquired carnotite claims in Colorado. Ore containing 640 mg. of radium was treated.

The Carnotite Reduction Co. supervised by Dr. H. N. McCoy purchased claims in Colorado, and began the erection of a reduction plant in Chicago.

A small quantity of ore was shipped to Europe. J. S. McArthur & Co. shipped one lot of ore from Utah to Glasgow, Scotland.

There has been considerable stress laid on the production of radium at a cost of about $40,000 per gm. by the National Radium Institute, as compared with a sale price of $120,000 per gm. charged by commercial producers. There has been some criticism of the commercial producers. The cost of production of radium by one of the largest producers is probably higher than the government cost, because the company was first in the field and has spent much money in experimental work. Even with a cost of $40,000 per gm. it is doubtful if a private manufacturer would find radium production profitable at a sale price of less than $80,000 per gm. because of the irregularity of the market.

New Deposits.—A pitchblende deposit of considerable size was discovered in the Singar district of Guya, India. Thorianite containing 93.02 per cent. thorium and 4.73 per cent. U_3O_8 was found in southeastern Madagascar. Monazite was reported 60 miles northwest of Pretoria, South Africa.

Metallurgy.—A complete report of the work and plant of the National Radium Institute[1] was published by the Bureau of Mines.

In the method of extraction used by the National Radium Institute, a high radium recovery is the object rather than a high uranium and vanadium recovery. The ore is ground to 20 mesh, and is leached with strong hot nitric acid in acidproof earthenware pots. The acid is kept near the boiling point with live steam. The charge is stirred with wooden paddles for about 15 min. and then dumped on an earthenware filter, where it is washed with hot water. The whole operation of leaching, filtering and washing takes about 7 hr. A new device for filtering has recently been installed which reduces the time considerably. The residue goes to the dump, and the solution to wooden tanks where it is diluted with water. The solution is stirred, and sodium hydroxide run in slowly to reach as nearly as possible the neutral point without forming a permanent precipitate. Barium chloride and sulphuric acid are stirred in for 1 hr., when the whole solution containing the barium sulphate precipitate is elevated to a conical settling tank, where it settles for 4 days.

[1] Extraction and Recovery of Radium, Uranium and Vanadium from Carnotite, *Bull.* **104,** C. L. Parsons, R. B. Moore, S. C. Lind, O. C. Schafer.

The solution is decanted into a tank containing boiling sodium carbonate, where the iron, calcium and most of the aluminium are precipitated, and the uranium and vanadium go into solution as the double carbonate of uranium and sodium, and sodium vanadate. The solution is boiled for 3 hr. after the acid solution is added.

The radium-barium sulphates and the associated liquor from the conical are run onto an earthenware suction filter, filtered, washed, and finally treated with dilute solution of sodium hydroxide in order to remove the last traces of free acid. The filtrate is run into the carbonate tank, and the sulphates dried.

The carbonate solution carrying the uranium and vanadium is nearly neutralized with nitric acid, the solution being constantly stirred with compressed air. Then sodium hydroxide is added to the boiling solution until there is complete precipitation of sodium uranate. The hot solution from the sodium uranate is completely neutralized with nitric acid, air being blown into the liquid in order to eliminate the carbon dioxide. Ferrous sulphate is then added, the liquid being continually agitated, and the iron vanadate precipitate filtered and washed.

The filtrate from the iron vanadate is almost wholly a solution of sodium nitrate, the main impurity being sodium sulphate. The solution is evaporated in iron tanks, and the crystals used to make fresh nitric acid for use in the plant.

The radium recovery averages 90 per cent. or better, the uranium about 85 per cent. and the vanadium 30 per cent.

A patent has been issued to C. W. Danforth, W. P. Samuels and W. T. Matersteck[1] on the extraction of radium from carnotite. The ore is crushed to 40 mesh and given an oxidizing roast. The roasted ore is treated with sulphuric acid which is said to fix the radium and barium present in the sands, and the vanadium and uranium go into solution. The sand is treated with caustic soda and sodium carbonate after washing with water, to make sulphate and silicates soluble, leaving the barium and radium as carbonates in the residues. These carbonates are dissolved with hydrochloric acid, the sulphates precipitated with sulphuric acid, and treated for radium.

[1] U. S. Patent 1126182.

SELENIUM AND TELLURIUM

By A. S. Callen

The year's demand for selenium has been much curtailed through absence of buying orders from the railroad for signal lamps and no possibility of shipments to Germany and Austria, although some metal was shipped from Baltimore to Rotterdam. The copper refineries have decreased production and even offer direct to consumers in small parcels. The price has ranged from \$2 to \$5 per lb.

Both the United States Metals Refining Co. and the Raritan Copper Works had interesting exhibits at the Chemical Exposition in New York, the Raritan bars being especially noteworthy for the large masses cast in vitreous form. Methods of production have been changed by some of the leading producers, the slags from the slimes furnaces being used rather than the flue dusts. It is impossible to estimate the production.[1]

Selenium is used chiefly in the manufacture of red glass and red enamel ware. The dioxide does not color the glass, but if reduced by carbon, by arsenic trioxide, or by fusing in a reducing atmosphere, the red color is obtained. This red color is probably due to the presence of a selenide, and not to colloidal selenium. The other uses of selenium are mainly laboratory uses, such as in the manufacture of selenium salts and in the production of selenium cells. Small amounts are used in medicine.

Tellurium acts as a coloring agent in glass only under reducing conditions, in which case it will give blue or brown colorations if present as a colloidal solution of the element, or a red if present as the polytelluride. The colloidal particles in the blue glasses are larger than those in the brown. The absorption spectrum of the red glass corresponds to that of an aqueous solution of polytelluride with a characteristic maximum between 480 and 490°. Color is obtained in the glass only under reducing conditions.

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

SODIUM AND SODIUM SALTS

By Samuel H. Salisbury, Jr.

The production of sodium and sodium peroxide is now attracting considerable attention. The latter is now manufactured exclusively from metallic sodium; it serves also as the starting point for the manufacture of sodium cyanide. The American production of sodium has been somewhat limited. The output has been used chiefly for the manufacture of peroxide. At present, there is an enormous demand for both sodium peroxide and sodium cyanide, the former for use chiefly in bleaching operations, the latter for use in metallurgy. Prior to the current war the bleaching and metallurgical interests of this country were largely dependent upon European sources for both salts.

The works at Niagara Falls, currently engaged in the manufacture of metallic sodium, are unable to meet more than a fraction of the present demand for this metal from manufacturers of sodium peroxide and from manufacturers of cyanide.

In view of the urgent necessities of a large group of American manufacturers, and of a multitude of manufacturing interests dependent upon the use of the bleaching agent, as well as upon the use of cyanides in the extraction of gold, it would appear as if the time is ripe for the establishment, upon a much larger scale than heretofore has been the case, of American production of sodium.

It is worthy of note in this connection that the mechanical equipment for the Castner process of the electrolytic manufacture of sodium from sodium hydrate (caustic soda) is exceedingly simple. The question naturally arises whether the many interests dependent upon these two vital salts may not find it advantageous to unite and organize without delay for the manufacture of metallic sodium. It would take but a few weeks for the firms now so well equipped for the construction of electrolytic devices to put up the necessary plant. The electrical equipment is of a standard character, and is probably kept constantly in stock.

It might also be noted that the full complement of electric power at Niagara Falls, guaranteed under the treaty of 1910, for use on the American side of the Falls, has not yet attained its maximum limit.

The Castner patents expired a few years since. The American output of caustic soda is now quite abundant. The available power at the Falls would be fully able to meet any additional demand in connection with the enlargement of the sodium industry.

The Darling process for the manufacture of metallic sodium has been utilized to some extent at Philadelphia. It is based upon the use of fused sodium nitrate as electrolyte. The mechanical equipment needed for the electrolytic decomposition of sodium nitrate is quite as simple as that employed in the Castner process.

It is also worthy of note at the present moment, when manufacturers of dye-stuffs and of high explosives, as well as a multitude of other chemicals, are struggling with the increasing shortage in the supply of nitric acid, that the acid mentioned is the only by-product resultant from the decomposition of sodium nitrate when exposed to the action of the electric current.

The prompt installation of the necessary plant for transforming Chile saltpeter (sodium nitrate) into metallic sodium, and into nitric acid, might be advantageously taken up under existing circumstances with great benefit to a large variety of consumers of both products.[1]

Japan.—A company has been formed at Osaka, Japan, with a capital of 350,000 yen for the manufacture of caustic soda. It is stated that the company intends to use the electrolytic process and is going to erect a factory in Kyushiu, where hydro-electric power is fairly cheap. The salt used will be Kwantung monopoly salt, the price of which for industrial purposes is 1s. 1½d. per cwt., but it is understood that a much cheaper rate has been arranged. The machinery is to be Japanese. As a by-product bleaching powder will be obtained, and one criticism of the scheme is that more of this will be produced than can be profitably sold. An output of 300,000 lb. of caustic soda per month is spoken of. The promoters of the company are said to be mainly dealers in salt, dyes and chemicals. The plans, however, have not so far progressed beyond the discussion stage.

At present there are two companies manufacturing caustic soda in Japan, one at Yamaguchi, and the other at Tokio. According to a newspaper report these companies produce about 6,000,000 and 700,000 kin respectively (about 3500 and 400 tons per annum), but little reliance is to be placed in these figures. Both these companies use the LeBlanc process. It is said that the main difficulties in the way of manufacturing soda products in Japan are (1) the price of salt, and (2) the absence of allied industries which would cheapen costs by providing a market both for the purchase of material and the sale of by-products.

[1] Thomas H. Norton, *Comm. Rept.*, Dec. 20, 1915.

Nitrate of Soda in 1915[1]

The complete exclusion of the principal Continental consuming countries (the northeastern districts of France being as hermetically sealed as Belgium) throughout the first full year of the European war rendered the nitrate trade somewhat akin to the play of "Hamlet" without the Prince of Denmark. Although, therefore, the quantities dealt with were far below the normal, the market—such as it was—partook of the most violent fluctuations known in the history of this characteristically volatile commodity. It will be sufficient to state that while the quotation for cargoes ranged between 9s. and 13s. 9d. per cwt., cost and freight, that for ordinary nitrate delivered free alongside ship in Chile varied from 5s. 8d. to 9s. 7d. per quintal. In the former case rising freights were *causa causans*, in the latter, speculation pure and simple. It is interesting to note that the lowest price ruled when production was at its nadir, and the highest when this was again going up by leaps and bounds. Premising that the enforced absence of particulars of "deliveries" robs the statistics of an important feature, we give the following figures for the past 2 years:

	1915, Tons.	1914, Tons.	Change, Tons.
Production	1,735,770	2,432,330	−696,560
Shipments:			
To Europe (including Egypt)	1,044,725	1,220,500	−175,775
To United States	813,000	533,200	+279,800
To other parts	117,000	71,000	+46,000
Total shipments	1,974,725	1,824,700	+150,025
Stocks in Chile, Dec. 31	799,400	1,091,600	−292,200

As already stated, production fell to its lowest point in February last year, when no less than a hundred oficinas had closed down, in addition to those previously idle, the month's output being under 80,000 tons; the total decrease in 1915 compared with 1914 was, as above, 696,560 tons, but the recovery was as rapid as the decline following the declaration of war in Europe, 112 oficinas being again at work at the end of the year. Many having continued to collect "caliche" (the raw material) were able on resumption to exceed their normal output, the total for the 3 months, October to December, being 709,130 tons, against 361,550 tons in the corresponding period in 1914, or twice as large. It reached 251,220 tons in December, against 110,400 tons in 1914 and 230,610 tons in 1913, Chile now actually turning out more nitrate than at the zenith of the industry. No wonder prices in Chile after steadily recovering during the first part of the year, and in the autumn rising like a rocket, came down like the stick on the cessation of speculative purchases when the evidence of overwhelming supplies could no longer be

[1] *Chem. Trade Jour.*, **56**, 69–70.

ignored. Matters were made worse by the increasing scarcity of tonnage, resulting in prohibitive rates of freight both for sailing vessels and for steamers, and while the closure of the Panama Canal has not, as implied in some quarters, affected the number available of the latter, it has, of course, lengthened the voyage, causing some delay. The *total* shipments in 1915 were, nevertheless, 150,000 tons larger than in 1914, the early decrease compared with the corresponding *antebellum* period being more than compensated by the increase in the latter months. This amounted for October–December alone to 275,000 tons, of which 190,000 tons went to Europe, 65,000 to the United States and 20,000 tons to other destinations, including Vladivostock, to which Siberian port nitrate was sent direct for transportation by rail to European Russia. The outstanding feature in the exports was the sudden expansion (279,800 tons) to America for munitions manufacturing purposes, the agricultural demand remaining stationary. In this connection it may be noted that the shipments to the United States have of late very considerably diminished, reaching only 142,000 tons in October–December, against 326,000 tons in June–August.

Of more immediate interest is the question of supplies for the coming spring season, and this in the absence of complete figures is again somewhat difficult to deal with. The general opinion expressed in the leading "trade reports" is that nitrate will be both scarce and dear, the intervention of the British government being ungraciously put forward as a contributive factor. There is no doubt that on account of the extraordinary rise in freight, prices are going to be much higher than in former years, and the supplies will be less; but it by no means follows that the *proportion* of the latter to demand will be lower. Failing details of "deliveries"—for some occult reason withheld since the beginning of the war—it is impossible to give exact figures; but there is nothing to prevent a fairly close estimate of the quantity of nitrate likely to be available.

France and England are alone of practical interest under existing circumstances, and as regards the former we need only say that it was quite recently officially announced in the Chamber of Deputies that all the nitrate required by French farmers will be at their disposal if ordered in time, in view of the congestion of the railways. This is easily understood, considering that while Dunkirk, the former chief recipient of cargoes, has been completely closed, the other ports (on the Western and Mediterranean coasts) received in the second half of 1915 no less than 157,000 tons, and in the first fortnight of January, 1916, a further 44,000 tons! The quantity "delivered" by those ports (excluding Dunkirk) in the 6 months to June 30, 1914; was 108,030 tons, according to the official returns, the total for agricultural purposes being quite insignificant in the second half of the year. Out of the 450,000 tons now "on passage" from Chile to Europe, at least 250,000 tons will be available for France, and it is therefore obvious that all her requirements both for agriculture and for "munitions" are amply secured far ahead, nor forgetting the relatively small part of the sugar-beet districts free from military operations.

Dealing in the same way with the United Kingdom, we find that the imports in the second half of 1915 were 141,920 tons. According to a leading trade circular, "consumption has probably been maintained during the past 6 months as far as agricultural quality is concerned, but the consumption of refined quality has, we should say, *trebled.*" Inasmuch as the *total* "deliveries" (including exports) from U. K. ports in the second or lean half of the year did not in normal times exceed 45,000 tons (of which, say, one-third, or 15,000 tons, for industrial purposes) it follows that, allowing for the said triplication in the case of "refined" nitrate, the deliveries in the past 6 months were at most 75,000 tons. This quantity would be supplied from the stocks available at June 30, 1915, which as a matter of fact were much larger, since 44,000 tons were imported in that month alone. At all events, stocks in the United Kingdom at Dec. 31 last can not have been less than 141,920 tons (imported in the preceding 6 months as above). The total "deliveries" in the half year to June 30, 1914, the last for which official figures are given, were 70,610 tons, and making allowance for a further large increase in the requirements for munitions, it would therefore appear that there was at the beginning of this year already enough nitrate in hand to meet the demand during the ensuing 6 months; this presupposing that the British farmer will buy as much as before the war—a highly improbable contingency in view of the prohibitive prices now asked for the Chilean fertilizer. To the actual existing supplies must, moreover, be added those "afloat" for Europe, amounting to 335,000 tons at Dec. 31, compared with 196,000 tons at the corresponding date in 1914. At a moderate computation 100,000 tons of the above fromidable total "on passage" will be discharged in this country before the end of May, and the list of prospective supplies is not yet exhausted, for the British government, anxious to assist the agricultural community, have purchased in Chile a large quantity of nitrate (said to be 50,000 tons) for delivery to farmers during the coming season. So far the necessary tonnage does not appear to have been secured, but the Transport Department having recently "requisitioned" a number of steamers to bring over the nitrate similarly bought for making explosives, the same course will in all probability be adopted in connection with the purchases for agricultural purposes. Even in the event of the government's benevolent intentions being temporarily frustrated—the *modus* *operandi* of distribution on arrival will be watched with greatest interest—the foregoing figures entirely disprove the claim put forward in trade circles of an approaching "nitrate famine."

It is said that "importers were deterred from making provision as usual for their season's requirements" by the government purchase aforesaid; but the statement, transparently intended to pave the way to high prices, is not likely to deceive the country dealers. They will, on the contrary, buy from hand to mouth as and when they receive orders from their customers, who, while perfectly willing to make free use of nitrate, are closely acquainted with the relative value of the different manures in the market. In spite of the recent rise, sulphate of ammonia is far cheaper than the Chilean product, and its freedom from market manipulation is a strong point in its favor. High prices for all commodities (farm produce not excepted) are unfortunately the order of the day; but the laws of supply and demand are not altogether in abeyance, and in the case of nitrate of soda the statistical evidence leans toward abundance rather than scarcity. A margin of supply of 100,000 tons—probably 150,000, possibly 200,000 tons—over last season's total consumption in England is surely sufficient to cover all extra agricultural, industrial, and military requirements in the current half year, and high freights are the sole justification for relatively high prices. It must be understood, however, that while the bulk of the nitrate was purchased in Chile on very favorable terms (nearer 6s. per quintal, f.o.b., than 8s.), it was shipped at rates much below those now ruling. According to a leading authority, "the majority of sailing-vessel fixtures are understood to have been made at about 55s. to 60s. per ton, and steamers at about 80s. per ton." These important points are conveniently ignored by holders whose present selling prices are consequently based on the maximum rates of freights, and represent profits bordering on the fabulous, even for the nitrate trade. Importers are not in business for their health, and it is perhaps their misfortune to deal in an article the cheapness of which is at present essential to the nation's welfare, however, made with full knowledge of the risk of seizure as "unconditional contraband of war," and the wonder is that the government did not long ago exercise the right of control of all supplies.

As will be seen from what has already been written, the position in Chile is one of deadlock, resulting from overproduction accentuated by scarcity of tonnage. The latter may be a blessing in disguise to the producers, since prices would inevitably have come down with a run in Europe had all the nitrate available been shipped, reacting on the local market. Large forward sales were made several months ago on favorable terms, and the prospect of indefinite postponement of delivery is not a pleasant one, more especially as many of the speculative buyers may not be able to carry out their contracts.

As matters stand, the stock in Chile at Dec. 31 last reached the formidable total of 799,400 tons, compared with 473,000 tons at the corresponding date in 1913, when the nitrate trade was in full swing, with tonnage in plentiful supply at 20s. per ton. To such an extent has production outrun consumption—dragging prices perilously close to the line between profit and loss—that negotiations are now taking place with a view to a combined reduction of output. The somewhat ostrich-like proposal is also under consideration of setting aside an "emergency stock" of 10,000,000 quintals (450,000 tons), saleable only above 7s. 6d.; the latest quotations are 7s. 0½d. and 7s. 4½d. for ordinary and refined respectively.

Germany's claim that she is henceforth independent of foreign supplies of nitrogenous fertilizers can be taken *cum grano*, the certainty being that she will again require large quantities of nitrate of soda after the war, and that these will in the first instance be supplied by German oficinas. The industry will right itself in the long run, but it will have to face a deadly competition from its synthetic rivals, and a drastic reduction of the Chilean export duty, instead of the enhancement recently contemplated, will be a *sine qua non* to success. Meantime a commodity, the prime cost of which does not exceed 3s. 6d. per cwt. in bulk on the congested drying-floors in Chile, is quoted 16s. per cwt. upward, delivered in bags in British ports, the users of "refined" quality (costing threepence more) being charged a premium of ninepence.

Nitrate in Chile (By Joseph T. Singewald, Jr., and Benjamin LeRoy Miller).—The outbreak of the European war caused a great collapse in the Chilean nitrate industry, and since the Chilean government is so largely dependent on the revenues derived from it, the government found itself very seriously embarrassed financially. Not only that, but the nitrate country being a barren desert incapable of supporting a population of itself, when the nitrate "oficinas" shut down, the workers had no means of support; and the government was forced to come to their rescue and transfer them to southern Chile where they could find means of livelihood.

The year 1915 was marked by a resumption of activities on the part of the nitrate producers and the nitrate workers were again sent back to the fields; during the latter part of the year, every ship going north from Valparaiso and southern Chilean ports carried these people in numbers far in excess of its steerage accommodations so that the decks had to be used by them for living quarters. At the end of the year production was normal and prices high, so that this important Chilean industry is again on a flourishing basis; the production reached 250,000 tons monthly and the New York quotations were around \$3.50 per 100 lb., which is \$1 higher than at the outbreak of the war. This increase in price represents in large measure increased ocean freights. From an American standpoint, an event of interest in the course of the year was a considerable increase in the holdings of the du Pont interests.

The Chilean nitrate region lies in the two departments of Tarapacá and Antofagasta, extending from latitude 19° to 26° south. Within this region are a number of more or less distinct producing fields which from north to south are known as the Tarapacá, the Tocopilla, the Antofagasta, the Aguas Blancas, and the Taltal, of which the first named has been by far the most important.

The rumor has been repeatedly circulated that the Chilean nitrate fields are approaching exhaustion. While it is true that they are not inexhaustible, there is no immediate cause for alarm, as the supply is ample to meet the demands for many years to come. Moreover, recent progress in the extraction of nitrogen from the air has removed the seriousness of such an eventuality. But the Chilean government still holds large areas of nitrate ground that is untouched. As demand for it arises, it is prospected by drilling by government engineers and the amount and grade of the nitrate it contains estimated. It is then sold at public sale to the highest bidder at so much per quintal (approximately 100 lb.). If no bid is regarded high enough, the land is withdrawn from sale and may be offered again at some future time. The price at recent sales has been at the rate of about 10 cts. per quintal. However, this land is not being taken up rapidly, as a large part of the output of nitrate is now coming from land that is being worked for the second and in some instances a third time. In the early days only the highest grade "caliche" was used. In re-working the ground, material running as low as 14 per cent. $NaNO_3$ is taken, though to this higher grade "caliche" is added to bring the average in the neighborhood of 20 per cent. to 25 per cent. $NaNO_3$. It is more feasible to re-work this old ground than to erect new "oficinas" and extend the railroads in undeveloped territory. At Paposas a new plant has just been erected to re-work such old ground by the Tarapacá and Tocopilla Nitrate Co., Ltd., at a cost of about £200,000 with a capacity of 90,000 to 100,000 quintals per month.

The method of elaboration of the crude nitrate in general use is very simple. The "caliche" is crushed and dumped into the boiling tanks, or "fondados," which are heated by coils of steam pipes. The material is subjected to leaching for 24 hr. with several changes of solution, at the end of which time what is left and known as the "ripio" carries 6 per cent. $NaNO_3$. This is thrown out on the "ripio" pile and its nitrate content lost. The hot nitrate solution, called "caldo," is run into large rectangular tanks, or "chulladores," in which colloidal mechanical matter settles and in which it is permitted to cool sufficiently to precipitate most of the sodium chloride. It is then run to a series of shallow tanks called "bateas" in which the nitrate crystallizes in from 3 to 6 days. The "mother-liquor" from these in re-used in the "fundados" and is also that from which the iodine is extracted. The crystallized nitrate is placed on the "cancha" or drying floor to dry and sack for shipment and carries 95 per cent. or more $NaNO_3$.

An event of the greatest importance in its possible bearing on the conservation of the Chilean nitrate supply was the installation during 1915 at the Agua Santa Oficina in the northern part of the Tarapacá field of the new Butters process of elaboration by means of which the nitrate content of the "ripio" is reduced from 6 per cent. to 2.5 per cent. If this process proves to be as successful as the results thus far achieved would indicate, it will make workable the whole of the old ground, even that which has been worked over for the second time. In fact this "oficina" is already planning to re-work ground averaging less than 12 per cent. $NaNO_3$. Instead of sending the crushed "caliche" directly to the "fundados," it is first passed over ¼-in. shaking screens and the undersize amounting to 20 per cent. of the whole removed. By removing this fine material, the extraction in the "fundados" is increased to such an extent that the "ripio" carries only 2.5 per cent. $NaNO_3$. The screening would be profitable, therefore, if the 20 per cent. of fines were thrown away, but their nitrate-content is also extracted. They are ground in a Hardinge mill whereby all of the nitrate is taken into solution, and the mechanical matter is removed by passing the mil lpulp through Butters filters. By washing the filter cakes with leaner solution their nitrate content is reduced to 4½ per cent., and it is proposed to recover this by washing last with a brine solution. This process yields a 25 per cent. increase in production from a 20 per cent. "caliche" with very little additional cost and hence promises to be a decided improvement over the old method.

Production

Turning to statistics, Mr. Thompson Aikman, jr., estimates the output for 1915 as 38,100,000 quintals, against 53,500,000 quintals in 1914 and 60,300,000 quintals in 1913; while shipments amounted to 43,500,000 quintals, compared with 40,100,000 quintals in 1914 and 59,500,000 quintals in 1913. The relative increase in shipments as compared with production somewhat flatters the market position, for the oficinas resumed work somewhat rapidly toward the end of the year, when 112 were reported at work, as compared with 36 in March. Estimates, especially of stock, are naturally somewhat uncertain at the present time, but the stocks in Chile to-day, according to Messrs. W. Montgomery & Co., are about 17,000,000 quintals. Production at the present time they estimate at about 5,400,000 quintals a month, a figure which clearly can not be maintained without piling up stocks at a great rate. The future is one of which it is impossible to speak with any certainty; there is no prospect of reduction in freights in sight, and under these circumstances the consumer can hardly look for any lowering in price.[1]

The following table shows the shipments and consumption of nitrate of soda for the last 13 years.

NITRATE OF SODA STATISTICS (*a*)
(In tons of 2240 lb.)

Year.	Shipments from South America.	Consumed in Europe.	Consumed in United States.	Consumed in World.	Stocks in Europe.	Visible Supply at Close of Year.
1902	1,360,000	1,028,000	214,000	1,259,000	263,000	660,000
1903	1,435,000	1,127,000	265,000	1,412,000	155,000	654,000
1904	1,476,000	1,131,000	275,000	1,447,000	162,000	672,000
1905	1,623,000	1,190,000	308,000	1,547,000	183,000	674,000
1906	1,700,000	1,243,000	355,000	1,636,000	190,000	733,000
1907	1,626,000	1,252,000	350,000	1,658,000	202,000	695,000
1908	2,017,000	1,378,000	309,000	1,732,000	402,000	928,000
1909	2,100,000	1,465,000	407,000	1,938,000	337,000	999,000
1910	2,300,000	1,651,000	501,000	2,241,000	310,000	969,000
1911	2,412,000	1,696,000	550,000	2,355,000	479,000	1,058,000
1912	2,478,000	1,908,000	481,000	2,508,000	310,000	1,004,000
1913	2,655,000	1,775,300	....	2,520,000	....	1,146,000
1914	2,005,000	....	....	....	....	....
1915	2,175,000	....	....	....	....	....

(*a*) Statistics of W. Montgomery & Co., London.

By decree No. 2157 of the Ministry of Hacienda, the scope of the loans to nitrate producers is extended to include nitrate works renewing operation and which have not a quantity of stored nitrate on hand. The law, No. 2918, promulgated in August, 1914, provided for a loan by the government of 3 pesos per Spanish quintal (101.4 lb.) of stored nitrate held by the producers, and of 4 pesos per Spanish quintal of nitrate at ports ready for shipment. Decree No. 2157 authorizes a government advance to nitrate producers at the former rate, even though the oficinas have no stock on hand, on the basis of the average production in periods of 3 months prior to the closing of the works.

The "Compania de Salitres de Antofagasta" proposes to construct new reduction works in the district of Salinas Norte, not far from Baquedano. It is estimated that the capacity of the new oficina will be about 2,000,000 quintals per annum. The same company has also recently purchased the oficina "Riviera," which has not been operating for a long

[1] *Min. Jour.*, Jan. 8, 1916.

time. This plant has a production of about 600,000 quintals per year. Completion of the new plant "Oficina Aguste Victoria," under construction for the firm of Gildmeister & Co., of Antofagasta, is now going on. Plants of other companies which have been idle since the outbreak of the war are again resuming operations, so that the nitrate supply will be able to supply any probable demand in the near future. Early estimates of the probable exportation in 1916 set the figure at 60,000,000 quintals.[1]

Niter in the United States

Practically no niter is produced in the United States, although a few deposits are known. All the nitrate consumed in this country is imported from Chile, the amounts being shown in the following table:

IMPORTS OF SODIUM NITRATE INTO THE UNITED STATES (a)
(In tons of 2240 lb.)

Year.	Quantity.	Value.	Value per Ton.	Year.	Quantity.	Value.	Value per Ton.
1904......	228,012	$9,333,613	$40.93	1910.....	529,172	$16,601,328	$31.37
1905......	321,231	11,206,548	34.89	1911.....	544,878	16,814,256	30.86
1906......	372,222	14,115,206	37.92	1912.....	486,352	16,668,404	34.25
1907......	364,610	14,844,675	40.71	1913.....	625,862	21,630,811	34.56
1908......	310,713	11,385,393	36.64	1914.....	541,715	15,228,671	28.11
1909......	422,593	13,281,629	31.43	1915.....	772,190	22,959,997	29.74

(a) As reported by the Bureau of Statistics, Department of Commerce. The figures of value appear to be doubtful, especially with respect to the earlier years.

The Homedale nitrate deposit[2] is located in and near the canyon of Sucker Creek, Ore., about 16 miles in a direct line southwest of Homedale, Idaho. While it may be possible to discover an increase in the size and number of nitrate-bearing veinlets, or perhaps even large veins, when the rock is opened farther, there seems little likelihood of any marked increase in richness within the interior of the rock mass. On the contrary, it appears more probable that the richest parts of the deposits are those already exposed in the faces and along the bases of the cliffs and that the material will be found to grow gradually leaner and perhaps to disappear altogether as the rock is penetrated.

The veinlets in the Homedale deposit which contain the niter and associated salts form a very small percentage of the rock mass. If it were practicable to leach the rock and remove the soluble salts without handling the rock itself, something might be done commercially with the niter. From the constitution of the country rock, however, it seems that little could be done without moving a relatively large amount of the rock, the cost of which would discourage commercial development.

[1] *Comm. Rept.*, Dec. 15, 1915.
[2] *U. S. Geol. Surv. Press Bull.*, September, 1915.

The Homedale deposits are similar to other deposits in sections all the way from Oregon to Texas that have been examined by the Geological Survey. The niter occurs on the surface and in cracks, forming in places rich veins in considerable quantity, but at no place yet examined has this superficial material seemed to lead to deposits extensive enough to have commercial value. Future investigations may, however, disclose a commercially valuable deposit, although the outlook at present is not very promising.

IMPORTS OF SODIUM SALTS (*a*)
(In tons of 2000 lb.)

	1911.		1912.		1913.		1914.		1915.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
Arsenate........	84.2	$5,199	178.3	$11,195	634.0	$55,941	114.1	$8,267	42.9	$2,188
Ash............	1,939.1	43,365	1452.7	33,459	1550.4	35,461	1,114.5	28,102	1,063.7	29,022
Bicarbonate.....	42.6	2,634	55.0	3,193	40.3	2,238	44.4	2,324	49.7	2,584
Bichromate and chromate.......	....	1	....	....	....	3	5.5	542	....	....
Caustic..........	1,492.1	73,968	465.3	28,937	335.7	25,364	332.7	23,914	222.1	19,318
Carbonate (crystal)........	152.6	4,235	177.3	5,616	84.6	2,928	103.7	309	72.2	2,748
Chlorate........	....	2	....	22	....	10	0.2	84	....	6
Chloride (salt)..	141,227.8	390,043	145,041	379,539	125,428	356,911	16,987.5	456,426	1,290.0	386,564
Hyposulphite....	14.7	612	4.3	277	3.6	228	463.1	128,828	927.6	268,693
Nitrate..........	546,394.6	17,101,155	481,786	15,427,904	656,672	20,713,375	620,533.2	17,926,165	644,415	16,240,510
Nitrite..........	238.8	21,205	487.3	47,399	634.8	57,595	922.2	76,813	848.8	74,267
Phosphate......	22.0	750	....	....	....	14	682.4	24,975	247.6	7,665
Prussiate.......	598.0	66,971	823.2	90,654	943.7	118,475	1,147.9	171,831	765.0	120,477
Sal soda........	107.2	1,512	126.8	2,020	64.0	1,010	81.8	1,274	52.4	606
Salt cake........	11,398.1	121,218	659	8,394	189.1	4,771	31.4	618	211.7	3,566
Silicate..........	617.3	11,713	466.6	8,870	516.1	9,400	523.3	10,881	744.0	16,292
Sulphide........	228.0	4,751	361.5	10,456	475.8	12,360	1,265.0	36,383	631.7	18,228
Sulphite........	493.7	14,810	177.1	4,860	13.6	400	191.3	5,627	82.8	4,316
Sulphate........	....	....	....	....	336.3	5,685	455.1	7,475	59.4	1,113

(*a*) For fiscal years ending June 30

Soda

Africa.[1]—About 25 miles north of Pretoria, at the famous "saltpan," a flourishing industry has grown up in the last few years. The well-known saline deposit on the farm Zoutpan has been proved to contain a large and valuable supply of carbonate of soda of increasing commercial importance in view of the growing needs of the market for that commodity on the mines. The deposit has on the surface an area of about 400,000 sq. yd., and its depth is probably very considerable. The deposit is now being turned to very profitable account by a company, known as the S. A. Alkali, Ltd., which has taken over its working on long lease from the government. The company is a Johannesburg one, with a capital of £25,000, and the directors are well-known local business men. The capital for the venture was, it is satisfactory to know, entirely subscribed locally, and the industry is in every sense, therefore, a legitimate local one meriting the fullest support. A small royalty is paid to the

[1] *So. Afr. Min. Jour.*, June 26, 1915.

government on the output, which ensures the State's sympathetic interest, though the latter has not yet taken the practical form of extending the very necessary railway facilities to the property.

The Magadi Soda Co., Ltd., was formed in 1911 principally to acquire a 99-years' lease of a deposit of natural soda covering an area of approximately 30 sq. miles, known as Lake Magadi, in Britiah East Africa, and to connect this area with the Uganda Railway by the construction of a branch line. In September last the shareholders were informed that owing to the situation in British East Africa arising from the war, the works at Magadi Lake were entirely suspended, and the port works at Kilindini, and other subsidiary works, were proceeding on a restricted scale only, and therefore, considerable delay must be anticipated before the company arrives at a producing stage. The report for the 12 months to Dec. 31 has now been issued, which states that as the company has not yet commenced trading, the completion of the works having been seriously interfered with by the war, it is impossible to submit a trading account. It would appear, however, that the work that has already been done has been put to good use, for the directors remark that the company's railway line and water supply have been of material service to the military authorities in British East Africa.

Salt

The salt industry is in some respects unique among the mineral industries. Although most of the metallic and of the other non-metallic industries reflect industrial world conditions and sometimes sharply fluctuate with them, the salt industry, presumably from its intimate association with the food supply of man, forges slowly but steadily ahead, generally keeping pace with the increase in population. There has been a steady downward trend in the cost of this most necessary commodity, owing to the abundant sources of supply and also to the great advances made in the last few decades in methods of manufacture. The widespread distribution of salt, however, has led to great multiplication of manufacturing plants, so that plant capacity has greatly outstripped demand. This has tended to lower prices and to increase greatly efficiency of operation in the plants that have survived the keen competition.[1]

Salt is prepared for market in various ways, the methods of production being divided into two distinct classes. This is owing in part to the fact that salt itself occurs naturally in two very distinct ways: (1) as rock salt in beds or associated with bedded or sedimentary deposits, and (2) as natural brines or bitterns. The larger part of our salt production

[1] W. C. Phalen, *U. S. Geol. Surv.*, 1915.

is derived by converting the rock salt into artificial brines, which are pumped to the surface and there evaporated.

The two methods of production referred to above are (1) the mining of rock salt and its purification and separation into marketable sizes and (2) the production of salt by evaporation of the artificial or natural brines bitterns, and sea water.

The principal processes hitherto employed in the manufacture of salt by evaporation are: (1) Solar evaporation; (2) direct heat evaporation, (*a*) in open kettles, (*b*) in open pans; (3) steam evaporation, (*a*) in jacketed kettles, (*b*) in grainers; (4) vacuum pan evaporation. Of the classes enumerated, direct heat evaporation in open kettles and steam evaporation in jacketed kettles have become practically obsolete.

In addition to the marketable salt thus produced, a very considerable quantity does not enter the market as such but is converted directly into sodium carbonate or bicarbonate or other sodium salts and is sold in these forms.

The States producing salt in the United States in the order of their production are as follows: Michigan, New York, Ohio, Kansas, Louisiana, California, West Virginia, Texas, Utah, Hawaii, Idaho, Porto Rico, Nevada, Oklahoma.

The production of salt in the United States is shown in the following table:

PRODUCTION OF SALT IN THE UNITED STATES (*a*)
(In barrels of 280 lb.)

Year.	California.	Kansas.	Louisiana.	Michigan. (*c*)	Nevada.	New York. (*c*)	Ohio, W. Virginia, and Pa. (*b*)	Texas.	Utah.	Other States.	Total, Barrels.
1905	664,099	2,098,585	1,055,186	9,492,173	(*d*)	8,359,121	2,728,709	(*d*)	177,342	1,390,907	25,966,122
1906	806,788	2,198,837	1,179,528	9,936,802	11,249	8,978,630	3,436,840	(*d*)	262,212	1,361,494	28,172,380
1907	626,693	2,667,459	1,157,621	10,786,630	6,459	9,657,543	4,007,390	(*d*)	345,557	464,143	29,719,495
1908	899,028	2,588,814	947,129	10,194,279	9,714	9,005,311	3,572,635	(*d*)	242,678	1,291,042	28,750,630
1909	886,564	2,769,849	(*d*)	9,966,744	16,107	9,880,618	3,835,267	(*d*)	246,935	2,505,562	30,107,646
1910	937,514	2,811,448	1,372,248	9,452,022	17,535	10,270,272	3,829,475	382,164	249,850	983,128	30,305,656
1911	1,086,163	2,159,859	(*d*)	10,320,074	12,856	10,082,656	4,485,886	385,200	272,420	2,391,710	31,196,824
1912	1,090,000	2,573,626	(*d*)	10,946,739	12,536	10,502,214	5,408,300	373,064	283,293	2,135,036	33,324,808
1913	1,082,993	2,698,079	(*d*)	11,528,800	8,971	10,819,521	5,424,056	355,529	330,443	2,189,913	34,438,305
1914	(*d*)	2,967,864	(*d*)	11,670,976	4,436	10,389,314	5,628,265	433,979	375,457	2,332,649	34,804,683
1915	....	....	....	....	....	....	....	....	....	....	38,231,496

(*a*) Statistics of the U. S. Geological Survey except for New York since 1905, which are from report of the State Geologist. (*b*) The production of Pennsylvania since 1905 is included in "Other States c) Includes brine used in manufacture of alkali. (*d*) Included in "Other States."

California.[1]—At Fairfield, San Diego Bay, Cal., the Western Salt Co. extracts salt from the ocean waters. The company owns about 900 acres of tide marsh which has been dredged and diked, on which a number of connecting ponds have been arranged. High tides occur about every 2

[1] *Min. Eng. World*, May 8, 1915.

weeks, and the ponds adjacent to the bay are filled with water which flows in at a strength of from 12 to 15 salinometer degrees. When these ponds are filled the flood gates are closed. After a few days the water is then pumped into the second ponds. It remains here a short time and is strengthened by solar evaporation, when it runs into the pickle ponds, carrying a density of about 66° of the salinometer.

CONSUMPTION OF SALT IN THE UNITED STATES
(In tons of 2000 lb.)

Year.	Production.		Imports.		Exports.		Consumption.	
	Amount.	Value.	Amount.	Value.	Amount.	Value.	Amount.	Value.
1901........	2,879,332	$6,617,449	201,733	$676,324	9,433	$86,414	3,071,632	$7,207,359
1902........	3,338,892	5,668,636	184,764	647,554	5,094	55,432	3,518,562	6,260,758
1903........	2,655,532	5,286,988	165,981	495,948	12,750	95,570	2,808,763	5,687,366
1904........	3,084,200	6,021,222	166,140	467,754	13,964	113,625	3,236,376	6,375,351
1905........	3,635,257	6,095,922	161,159	492,189	34,238	239,223	3,762,178	6,348,888
1906........	3,944,133	6,658,350	170,505	502,583	33,988	274,627	4,080,650	6,886,306
1907........	4,160,729	7,439,551	153,435	452,227	30,802	232,895	4,283,362	7,658,883
1908........	4,024,345	7,486,894	156,609	440,484	26,627	202,338	4,154,327	7,725,040
1909........	4,215,070	8,343,831	158,487	447,983	40,158	269,273	4,333,397	8,522,541
1910........	4,242,792	7,900,344	142,549	388,015	49,013	320,926	4,336,328	7,967,433
1911........	4,365,756	8,345,692	137,759	378,083	48,873	335,285	4,454,642	8,397,490
1912........	4,665,473	9,402,772	136,391	361,664	62,410	418,525	4,739,454	9,345,911
1913........	4,821,368	10,123,129	150,601	416,375	70,289	515,194	4,901,680	10,024,310
1914........	4,872,656	10,271,358	130,752	385,752	82,295	586,055	4,921,113	10,071,055
1915........	5,352,409	11,747,686	123,576	366,475	80,474	613,850	5,395,511	11,500,311

Here the brine reaches a strength of 100 salinometer degrees, or a specific gravity of 1.201; all gypsum, magnesia salt and other foreign matter has been deposited. The brine is then moved to the crystallizing ponds. In the latter ponds, when a specific gravity of 1.235 is reached, the salt begins to crystallize, and at 1.235 to 1.252, salt is deposited, after which the remaining brine, known as bittern water, is pumped out. As the bittern water is pumped out, new brine is added from the pickle ponds; thus the process continues until salt to a depth of about 10 in. is deposited. Nine inches is estimated to yield 1800 tons per acre.

The pond is now drained and workmen are set to work. Tracks are laid and small dump cars are hauled in by gasoline engines. The loaded cars are transferred to an electric railway, and thence to the washing plant, where the salt is raised by bucket elevators and distributed into piles.

Both washing and elevating methods are novel and effective. The salt is dumped from the cars into a trough, in which is a screw conveyor. From here the salt is conveyed to buckets, which lifts it a few feet to a washing trough. While the salt is moved along by the screw conveyor, it is washed by water saturated with brine flowing in opposite direction. The salt is raised from the washing trough by a conveyor having buckets made of wire mesh. These buckets pass under a stream of brine, cleaning the salt of any remaining foreign matter. During the ascent a spray of fresh water gives it a final wash. This conveyor raises the salt to the top of a trestle where it is dumped into a trough, and by a screw conveyor it is conveyed and dumped into piles, where it awaits shipment.

When completed, the plans will permit of a production of about 40,000 tons of salt annually.

Hawaii.—One of the minor products of the Hawaiian Islands is salt, the output for 1915 having been 2400 tons. Most of the salt produced in the islands is the output of the Honolulu Salt Co. whose product is confined to coarse salt and manufactured entirely by solar evaporation.

Foreign Countries

England.[1]—According to the annual statistics compiled by the Salt Union, Ltd., notwithstanding all the complexities of the war, the exports of salt from Liverpool and the Manchester Ship Canal ports (401,977 tons) were rather larger than in 1914 and not very much less than in 1913. The coastwise shipments were much reduced by the inactivity in the fisheries of the United Kingdom. To the United States there was some decrease through lack of ship room and advance of freights. To British North America the figures for the past 3 years are almost exactly equal which under all the circumstances is not a little remarkable. The West Indies and Central and South America exhibit some increase on both the 2 previous years. The African trade in spite of the endless difficulties about shipments shows a great increase, the total exceeding that in any of the previous 10 years. To Asia there was a considerable recovery from the low tonnage of 1914, although ship room was scarce and dear; indeed the figure of 1913 was almost reached. The decline to Australia was due to lack of ships. To Europe the total of 1914 was the largest for many years and under all the circumstances it is not surprising that the figure for 1915 is less.

Canada.—During 1915 it is estimated that Canada produced 119,900 tons of salt valued at $600,226.

China.[2]—The Chinese government it is said, in order to improve the condition of Chinese salt, will shortly establish a salt refinery at Hankow for manufacturing or refining salt for the consumption of foreigners in the various treaty ports and for checking the annually increasing importation of foreign salt into China. The services of some foreign experts will be secured for this purpose by the Chinese government. The government is paying great attention to this enterprise for the preservation of the salt monopoly and other refineries will be established if the proposed factory at Hankow proves successful.

[1] *Chem. Trade Jour.*, Feb. 19, 1916.
[2] *Chem. Trade Jour.*, Mar. 25, 1916.

Russia.[1]—According to the Association of Miners of South Russia, the amount of salt produced in the Don district in 1914 reached 38,030,000 poods (about 684,500 short tons), which, compared to the production of 1913, shows a reduction of 2.5 per cent. However, compared with the average production of the last decade, the above figures show an increase of 13.1 per cent.

The principal centers of salt production are Bakhmut and Slaviansk. In Bakhmut the output amounted to 27,740,000 poods (499,300 short tons) of rock salt and 319,000 poods (5700 short tons) of evaporated salt. In the first case the production, compared with that of the preceding year, showed a decrease of 6.9 per cent.; in the second case a decrease of 36.6 per cent. In Slaviansk the results were more satisfactory; the amount of evaporated salt obtained reached 9,970,000 poods (179,500 short tons), which, compared with the yield of 1913, showed an increase of 14.3 per cent. No rock salt is found in Slaviansk.

The exports of salt from the Don district during 1914 were 676,000 short tons, 3.7 per cent. less than in 1913. During the first 6 months of 1914 there were shipped 312,300 short tons from the Don district, against 311,800 short tons shipped during the corresponding period in 1913; during the second half of the year the shipments of salt amounted to 361,700 short tons, against 388,000 short tons exported during the second half of 1913.

Sicily.—The production of salt in Sicily is carried on at Trapani. The output during 1914 was about the same as in the preceding year—namely, 200,000 tons. Certain grades were scarce on account of the rains. The exportation the first half of the year was quite favorable, but the war materially affected this trade. By the end of July, 135,000 tons had been exported, while the amount for the remainder of the year was but 15,000 tons. Norway and Sweden were the largest purchasers, taking 105,000 tons; the Netherlands imported 15,000 tons and the United States 14,000 tons.

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SULPHUR, PYRITE AND SULPHURIC ACID

By Samuel H. Salisbury, Jr.

Sulphur

Last year the United States surpassed the other great sulphur-producing center—Sicily—and now occupies the dominating position in the sulphur industry of the world, Italy ranking second. This was due more to the decreased production by the Sicilian mines than to any large increase in production in the United States, which remained about normal.

The imports of crude sulphur into the United States during 1915 were 24,647 long tons valued at approximately $405,990, an increase over 1914 of almost 2000 long tons, the figures for the year 1914 being 22,810 long tons valued at $409,537. A considerable amount of this increase was due to the increased activity of the Japanese sulphur business, practically no Sicilian sulphur reaching this country last year.

Sulphur production in the United States in 1915 was probably the greatest in the history of the industry. Louisiana and Texas furnished practically the whole output, the former State supplying the major part of this production as heretofore. The Union Sulphur Co., at Sulphur, La., maintained in 1915 its normal yearly output of about 375,000 tons, with four wells. In Texas, the Freeport Sulphur Co. added a third steaming plant at the Bryan Heights dome and was producing at the end of 1915 at the rate of about 300 tons per day; no figures of the year's output were obtainable from the company. No production except for local consumption was made in other States of this country, and the same was true of the other Americas.

The sulphur trade in the United States was decidedly slack during the first half of 1915, but improved gradually until at the end of the year there was a brisk trade. Stocks at the end of 1915, however, were greater than at any previous time. The slack conditions in the paper trade in the first half of the year reduced domestic consumption in 1915 to less than 300,000 tons. Export business was practically suspended owing to transport conditions, but late in the year the Union Sulphur Co. made two small shipments to Sweden and purchased a 9000-ton steamer preparatory to resuming shipments to some of its European distributing stations. Prices remained practically stationary in the United States, but the Consorzio, which controls the Silician sulphur sales, is reported to have raised its prices late in the year. Japan at midyear was producing at an increased rate.[1]

SULPHUR IMPORTS AND EXPORTS OF THE UNITED STATES
(In tons of 2240 lb.)

Kind.	1910.		1911.		1912.		1913.		1914.		1915.	
	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value.	Amt.	Value
Imports:												
Crude.......	28,647	$495,988	24,250	$436,725	26,885	$494,778	14,636	$278,056	22,810	$409,537	24,647	$405,990
Flowers......	912	30,180	3,891	83,491	1,310	39,129	5,899	115,574	621	17,214	647	23,146
Refined......	985	25,869	986	24,906	1,665	40,933	1,234	29,091	1,800	47,568	988	30,335
Precipitated..	47	6,489	68	8,643	66	9,137	350	17,690	105	14,161	85	12,987
Total imports....	30,544	$552,037	29,127	$545,122	29,860	$574,837	22,119	$440,411	25,336	$488,490	26,367	$472,458
Exports......	30,742	552,941	28,103	545,420	57,736	1076,414	89,221	1,559,761	98,163	1,807,334	37,312	724,679

MARKETED PRODUCTION OF SULPHUR IN THE UNITED STATES, 1880–1914, IN LONG TONS
(U. S. Geol. Surv.)

Year.	Quantity.	Value.	Year.	Quantity.	Value.
1904...............	127,292	$2,663,760	1910................	255,534	$4,605,112
1905...............	181,677	3,706,560	1911................	265,664	4,787,049
1906...............	294,153	5,096,678	1912................	303,472	5,256,422
1907...............	293,106	5,142,850	1913................	311,590	5,479,849
1908...............	369,444	6,668,215	1914................	327,634	5,954,236
1909...............	239,312	4,432,066			

Sulphur Mining in the United States

Louisiana.—The Union Sulphur Co., at Sulphur, La., maintained in 1915 its normal yearly output of about 375,000 tons, with four wells.

Texas.—The opening of a sulphur mine at Freeport, Tex., near the mouth of the Brazos River, has given a new impetus to the sulphur industry in the United States and the splendid production that is being secured assures for this country another great source of supply of sulphur.

It has been known for years that there were deposits of sulphur at this point, but it was not until about 3 years ago that actual work in their successful operation began. Real operation began some 2 years ago and the success of the production up to this time leads to the conclusion that the Freeport sulphur mines will compare favorably with any in the world.

The sulphur produced at these mines is remarkably pure. While it is classed as crude, it is sold on a commercial guarantee of 99.5 per cent. pure, and it often grades as high as 99.9 per cent. pure.

The plant has been increased since the operation began, very materially. It now has a boiler capacity of 12,000 hp., and their energy is all

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

devoted to the operation of the plant, which is in operation day and night. It has every modern appliance and is regarded as one of the most complete plants in the country.

An interesting experiment is now being undertaken in the hope of effecting a large economy in heating mine water. The natural heat of the subterranean water in the formation is 105°. As the water is now delivered to the plant for heating, its temperature varies with the season from 40 to 90°. To raise this water to a temperature of 336° obviously consumes more fuel than from 105°. The formation water, however, carries heavy scale-forming properties, and especial equipment has been designed to prevent the precipitation of this scale within the heaters or piping.

An area of several hundred acres, chiefly under the mound known as Bryan Heights, has been demonstrated as containing sulphur, and a complete plan of carrying on investigations as to the area is under way, so that the richest spots may be located. The present output is satisfactory, but there may be territory of much greater richness than now under devleopment, which will be determined by systematic exploration.

The plant is admirably located, in that it is within 3 miles of the port of Freeport, which has been improved to a depth of 18 ft.

Foreign Sulphur Industry

Chile.—(By Benjamin L. Miller and Joseph T. Singewald, Jr.). During 1915 the sulphur industry of Chile exhibited unusual activity and the production was much in excess of any previous year. Plans for still further increasing the output were formulated, and if carried out, will require the companies to look about for new markets for their product. At present the vineyards of south-central Chile consume practically the entire production.

Chile, and also Peru, contains a number of undeveloped sulphur deposits which, as yet, have received little attention. The sulphur is of volcanic origin and is found high up on the flanks of the recent extinct volcanoes that are such prominent features in the western range of the Andes. Many of these mountains still have active fumaroles and the sulphur is continually being formed from the sulphurous gases in the interstices of the rocks.

The greatest obstacle in the working of the deposits is due to the elevations at which they occur. Few of them are less than 14,000 feet above sea-level and some of the best are about 20,000 feet. The difficulties of working these highest deposits are so great that no efforts have been made to operate them. So far as known the highest deposist now worked are on the top of Mt. Olca at an elevation of 18,500 feet and on Mt. Chupiquina at about 19,000 feet.

The difficulties of transportation have hindered the development of the sulphur industry of the country and now, with two railroads crossing the belt, this has been in part remedied, but the greater number of deposits still remain untouched.

The active regions are two in number, the Ollague district along the line of the Antofogasta-La Paz Railroad and the Tacora district through which the Arica-La Paz railroad passes.

The Ollague workings are on the steep south slopes of Mt. Ollague a short distance below the great active fumarole that is continually emitting sulphurous gases and steam visible twenty miles away. There is a large quantity of practically pure sulphur, which alone is taken, while the rich sulphur rock or caliche, is discarded. The sulphur is taken to the railroad station at Ollague on the backs of llamas or burros.

On Mt. Olca which lies about 8 miles east of Yuma, a station on the Collahuasi branch railroad, and through the summit of which the Chilean-Bolivian boundary line passes, there are two companies engaged in mining sulphur. Here also only the pieces of practically pure sulphur are sacked for hauling to the railroad.

In the Tacora district four companies were in operation during 1915. Here the caliche is of lower grade and all of it is refined by volatilization before shipment. One company, Muecke and Co., have an aerial tram from their deposits high up on Mt. Chupiquina to Chislluma, about 5 kilometers away, where their oficina and refining retorts are located. Another company, Espada Hermanos, was engaged during the year in the construction of a narrow gauge steam railroad 22 kilometers in length to haul the caliche from the mines on Mt. Tacora to their oficina located along the Arica-La Paz railway between Ancora and Humapalca.

The Tacora district contains an abundance of yareta, a moss-like plant that forms thick compact masses on the rocks and contains much resinous material which makes it an excellent fuel. Without this useful plant growth the sulphur could not be refined in the district with profit

Japan.—The export of sulphur from Japan has for years been on the decline, and quotations have fallen, some of the sulphur mines of small standing having even been compelled to stop working. But since the war broke out the demand in the foreign market has improved, and quotations have gradually risen. The export to the end of August, 1915, was 27,948,607 lb., valued at $203,048, showing an increase of 4,638,451 lb. or $20,003, compared with the figures for the corresponding period of last year. The destinations have in the past been the United States and Australia in the main, with Canada and India coming next, only quite an insignificant amount being shipped to Europe. Since the war, however, the European supply to oriental countries has been stopped, and the demand in Europe itself has increased. Therefore, Japanese sulphur has now to meet an increased demand in the Orient and America and also in Europe. The prospects of this trade are, therefore, very promising, and it is expected that the volume of trade will soon become as big as it was several years ago when the sulphur trade was on the high tide of prosperity.[1]

Several orders for sulphur have been received by Japanese merchants from the United States and Australia. Already something like 10,000 tons, at $14.94 per ton, have been sold. Russia has begun to buy in Japan recently, though in small quantities. The visible stock in Osaka and Kobé has fallen off from 2000 tons to 1000 tons. In the producing districts also the stock is very small, and there is little prospect of its being replenished at an early date, as the mines will be closed for the winter months. The price is, in these circumstances, on the upgrade, the progress being quite rapid. Powder sulphur, especially, has increased rapidly in price. During November it advanced from $28 to $39.84 per ton.[2]

Italy.—Owing to the fact that the domestic supply of crude sulphur in the United States meets the demand, none was exported from Sicily to that country. Further, the United States now actively competes with Sicily in crude sulphur in the European markets. The decline in Sicilian exports is in part due to this competition, to the increased use of pyrites as a sulphur substitute, and to the paralysis of trade consequent to the war.

The production during the year was 334,974 metric tons, an amount less than the preceding year. In fact, the production for several years past has declined, probably due to lack of capital for financing and to the shutting down of some of the large mines on account of fires.

The increased cost of the extraction of the ore at the mines induced the producers to petition the government syndicate that controls the sale of the sulphur (Consorzio Obbligatorio per l'Industria Solfifera Siciliana) to advance prices, which request was granted in July, 1914.

The Consorzio's prices per metric ton of crude sulphur in bulk on board lighters at the port of Girgenti, Sicily, before and after July, 1914, are given in the following table:

Quality.	Purity.	Jan.–July.	Aug.–Dec.	Quality.	Purity.	Jan.–July.	Aug.–Dec.
	Per Cent.	Per Ton.	Per Ton.		Per Cent.	Per Ton.	Per Ton.
Yellow superior....	99	$19.30	$19.78	Brown superior.	96	$18.72	$19.20
Yellow inferior.....	97	19.11	19.59	Brown inferior.	95	18.53	19.01

[1] *Comm. Rept.*, Nov. 3, 1915.
[2] *Comm. Rept.*, Feb. 7, 1916.

Crude sulphur in bulk is seldom shipped from Catania. The Consorzio convey it here for refining and milling purposes and supply only enough to about fill the demand, and in order to discourage its export in the natural state from this port the syndicate has established a higher price from Catania than from Girgenti.

Refined and milled sulphurs which are chiefly exported from Catania met a fairly active demand during the year. Local competition is keen and profits small. Owing to the increased cost of refining, increased prices of bagging, and cost of wood for the casks, prices for sulphurs have advanced.

The market prices of refined and milled sulphur at the end of 1914, per metric ton f.o.b. Catania (in 112-lb. sacks), were as follows: Sublimed flower of sulphur, $34.35; refined sulphur in rolls, $27.98; refined sulphur in lumps, $28.79; and refined ground sulphur, $25.09.[1]

TOTAL EXPORTS OF SULPHUR FROM SICILY, 1906–1914
(In metric tons)

Country.	1907.(*d*)	1908.(*d*)	1909.(*d*)	1910.(*d*)	1911.(*d*)	1912.(*d*)	1913.(*d*)	1914.(*d*)	1915.(*d*)
Austria	26,390	22,086	26,560	29,601	34,136	38,362	36,335	25,306	70
Belgium	8,066	8,746	16,377	14,305	11,771	10,723	13,321	5,975	....
France	59,868	96,448	90,239	93,229	114,868	104,109	21,582	60,773	96,156
Germany	35,059	30,229	28,538	30,225	28,664	32,286	31,042	18,826	391
Greece and Turkey	27,969	24,838	16,309	21,435	24,933	15,436	20,112	20,746	19,857
Holland	14,951	9,812	8,708	9,731	10,549	14,019	8,976	8,080	1,163
Italy	57,743	60,134	49,692	61,269	72,959	84,952	85,740	97,170	116,601
Portugal Spain	13,328	17,586	21,036	18,758	25,121	21,314	21,445	17,604	21,004
Scandinavia (*c*)	23,415	30,366	19,905	20,354	29,741	35,111	28,108	25,294	24,832
Russia	21,244	14,068	18,584	25,866	23,485	25,563	25,891	21,290	2,791
United Kingdom	17,929	20,597	19,860	19,074	19,936	19,830	16,052	12,991	36,156
United States	4,047	9,654	14,706	12,205	8,482	2,856	1,028	1,406	2,054
Other countries(*b*)	31,942	30,509	33,999	36,935	49,181	42,731	54,185	22,883	38,731
Totals	341,951	375,037	364,513	393,987	453,826	447,292	414,717	338,344	359,806
Stock in Sicily, Dec. 31	594,459	616,419	647,880	640,711	551,442	450,917	376,365	369,001	323,391

(*a*) Reported by Emil Fog & Sons, Messina. (*b*) Mainly South Africa, Northern Africa, Asia, Australia, and the East Indies. (*c*) Including Norway, Sweden and Denmark. (*d*) Reported by Parsons & Petit, New York. (*e*) Includes Canada.

New Zealand.—Sulphur deposits are found on White Island, in the Bay of Plenty on the coast of the North Island of New Zealand, about 30 miles from the main land. This island, which covers about 600 acres, attains a height of 900 ft. on one side and opens to the sea on the other. Its topography indicates an old crater, and the boiling lake on the island, which is one of the awe-inspiring sights of New Zealand, is a further evidence of volcanism. After the New Zealand Sulphur Co. had spent $100,000 in preparation for mining sulphur in this locality, a volcanic disturbance wrecked the camp and killed 10 men.[2]

[1] *Comm. Rept. Suppl.*, Aug. 18, 1915.
[2] *Min. Amer.*, Dec. 25, 1915.

WORLD'S PRODUCTION OF SULPHUR (*a*)
(In metric tons)

Year.	Austria. (*b*) (*e*)	Chile.	France. (*b*)	Germany.	Greece.	Italy. (*b*)	Japan.	Spain.	United States.	Total.
1898......	589	1,256	9,818	1,954	135	502,351	10,339	(*b*)3,100	2,770	532,312
1899......	671	989	11,744	1,663	1,150	563,697	10,241	1,100	1,590	592,290
1900......	985	2,472	11,551	1,445	891	544,119	14,439	750	4,630	581,282
1901......	5,048	2,516	6,836	963	2,336	563,096	16,548	610	6,977	604,930
1902.... ..	3,826	2,636	8,021	487	1,391	510,333	18,287	450	7,565	552,996
1903......	4,610	3,560	7,375	219	1,266	553,751	22,914	1,680	35,660	631,035
1904......	6,431	3,594	5,447	209	1,225	527,563	25,587	605	196,588	767,249
1905......	8,542	3,470	4,637	205	1,126	568,927	24,652	610	218,440	830,609
1906......	15,258	4,598	2,713	178	(*d*)1,000	499,814	27,589	700	298,704	845,956
1907......	24,199	2,905	2,000	176	(*d*)1,000	426,972	33,329	3,612	312,731	801,911
1908......	17,429	2,705	2,189	811	(*d*)1,000	445,312	33,419	13,872	312,700	829,437
1909......	12,856	4,508	2,900	1,185	(*d*)1,000	435,060	36,317	21,750	303,000	817,608
1910......	15,976	3,823	2,641	1,272	....	430,360	43,848	30,113	259,699	787,732
1911......	15,856	4,451	1,200	1,251	174	414,671	52,064	40,662	246,300	776,629
1912......	14,979	4,431	1,000	(*c*)	2,016	357,547	55,005	42,344	308,530	785,852
1913	10,561	(*c*)	659	......	*Nil*	349,602	59,481	62,653	316,783	....
1914......	....	......	....	......	*Nil*	403,558	....	....	333,095	....

(*a*) From the official reports of the respective governments. The sulphur recovered as a by-product by the Chance-Claus process in the United Kingdom, amounting to between 20,000 and 30,000 long tons annually, is not included. (*b*) Crude mineral; limestone impregnated with sulphur. (*c*) Not yet reported. (*d*) Estimated. (*e*) Includes such production from Hungary.

Pyrite

Under normal conditions the United States imports about three times as much pyrite as it produces. During 1915, however, the amount imported was considerably less than usual due to high rates and scarcity of bottoms. The average prices were somewhat higher than heretofore, being about 15 cts. per unit as against 13½ before the war. It is estimated that the amount of pyrite imported from Spanish and Portuguese ports during 1915 was not much over 900,000 tons.

PRODUCTION, IMPORTS AND CONSUMPTION OF PYRITE IN THE UNITED STATES (*a*)
(In tons of 2240 lb.)

Year.	Production.		Imports. (*b*)		Consumption.	
1900..................	201,317	$684,478	322,484	$1,055,121	523,801	$1,739,599
1901..................	234,825	1,024,449	403,706	1,415,149	638,531	2,439,598
1902..................	228,198	971,796	440,363	1,650,852	668,561	1,622,648
1903..................	199,387	787,579	425,989	1,628,600	625,376	2,416,179
1904..................	173,221	669,124	413,585	1,533,564	586,806	2,202,688
1905..................	224,980	752,936	515,722	1,780,800	740,702	2,533,736
1906..................	225,045	767,866	597,347	2,138,746	822,392	2,906,612
1907..................	261,871	851,346	656,477	2,637,485	918,348	3,488,831
1908..................	206,471	744,463	668,115	2,624,339	874,586	3,368,802
1909..................	210,000	756,814	692,385	2,428,638	902,385	3,185,452
1910..................	223,700	830,150	806,590	2,773,627	1,030,290	3,603,777
1911..................	299,904	1,150,597	1,001,944	3,788,632	1,301,848	4,939,229
1912..................	350,928	1,334,259	964,478	3,860,738	1,315,406	5,194,997
1913..................	341,338	1,286,284	850,592	3,611,136	1,192,930	4,897,421
1914..................	336,662	1,283,346	1,026,617	4,797,326	1,363,279	6,080,672

(*a*) These statistics do not include the auriferous pyrite used for the manufacture of sulphuric acid in Colorado. (*b*) Net imports, less re-exports.
U. S. Geological Survey.

The domestic production of pyrite comes principally from the States of Virginia, California and New York, the States being named in the order of their tonnage production. In addition pyrite is mined in the States of Georgia and Missouri and is obtained in the States of Illinois, Indiana and Ohio as a by-product of the coal-mining industry. Some pyrite is also produced in Wisconsin in connection with the zinc-mining industry.

WORLD'S PRODUCTION OF PYRITE
(In metric tons)

Year.	Belgium.	Bosnia.	Canada.	England.	France.	Germany.	Hungary.	Italy. (*a*)
1900	400	1,700	36,308	12,484	305,073	169,447	87,000	71,616
1901	560	4,570	31,982	10,405	307,447	157,433	93,907	89,376
1902	710	5,170	32,304	9,315	318,235	165,225	106,490	93,177
1903	720	6,589	30,822	9,794	322,118	170,867	96,619	101,455
1904	1,075	10,421	29,980	10,452	271,544	174,782	97,148	112,004
1905	976	19,045	29,713	12,381	267,114	185,368	106,848	117,667
1906	908	13,474	35,927	11,318	265,261	196,971	112,623	122,364
1907	397	3,671	35,494	10,357	283,000	196,320	99,503	126,925
1908	357	5,000	42,934	9,599	284,717	219,455	95,824	131,721
1909	214	(*b*)	58,645	8,564	273,221	198,688	98,971	149,084
1910	213	571	48,871	10,393	250,432	215,708	92,464	165,688
1911	122	3,118	74,978	10,276	277,900	217,459	96,754	165,273
1912	148	6,216	73,944	10,691	282,202	242,121	103,809	277,585
1913	268	3,242	207,532	11,611	311,167	(*g*)228,405	106,629	317,334
1914	....	4,459	207,182	....	....	....	....	335,531

Year.	Japan.	Newfound-land.	Norway. (*c*)	Portugal. (*c*)	Russia.	Spain.	Sweden.	United States.	Total.
1900	16,166	*Nil*	98,945	402,870	23,154	34,638	179	204,538	1,464,512
1901	17,589	7,532	101,894	443,397	30,732	33,953	*Nil*	238,582	1,568,999
1902	18,580	26,000	121,247	413,714	26,465	145,173	*Nil*	231,849	1,713,654
1903	16,149	42,674	129,939	376,177	22,780	155,739	7,793	202,577	1,692,812
1904	24,886	61,166	133,603	383,581	31,667	161,841	15,957	175,992	1,696,099
1905	25,569	51,534	162,012	352,479	30,689	179,079	20,762	228,580	1,789,816
1906	36,038	28,583	197,886	350,746	20,660	189,243	21,827	228,646	1,832,475
1907	56,166	28,000	236,038	241,771	18,316	225,830	27,000	266,061	1,854,849
1908	33,867	(*e*)35,000	269,129	81,417	56,345	263,457	29,569	209,774	1,768,365
1909	27,066	*Nil*	282,606	284,735	46,078	236,000	16,104	213,371	(*e*)1,730,000
1910	78,418	*Nil*	322,000	312,906	55,980	294,184	25,445	227,280	1,826,854
1911	73,879	2,500	(*e*)350,000	282,773	113,054	344,879	30,096	304,974	2,348,035
1912	74,929	*Nil*	469,326	(*f*)601,443	123,990	421,070	31,835	356,707	3,076,016
1913	114,589	....	441,129	(*f*)391,083	....	926,913	34,319	347,027	3,441,245
1914	....	....	....	....	....	....	....	342,273	....

(*a*) Cupriferous in part. (*b*) Reports not yet available. (*c*) Both iron and copper pyrites. (*e*) Estimated. (*f*) Includes 120,148 tons copper iron pyrite in 1912 and 13,550 tons in 1913. (*g*) Prussia alone.

Foreign Pyrite Industry

Canada.—During 1914 there was exported from the Province of Ontario pyrite to the value of about $350,000, all of which went to the United States. Of the five companies producing pyrite in the province only one produced acid at the mine. More than one-half of the total production of the province was mined at North Pines in the Fort William district.

During 1915 it is estimated that Canada produced 296,910 short tons of pyrite valued at $1,028,678.

Norway.—The total pyrite produced in Norway in 1914 was about 430,000 tons which was taken from Sulitjelma, Stordoe, Bossmo, Foldal, Roestvangen and Roros mines. Of this amount 358,114 tons were exported or about 70,000 tons less than during 1913. For home consumption about 60,000 tons were reserved and 42,852 tons of purple ore was exported. The Norwegian pyrite exported is estimated at about one-tenth of the total European shipments.

South Africa.—The possibility of pyrite mining as an industry in this country has had attention drawn to it at various times as a result of the demand for sulphur for the production of sulphuric acid, of which a considerable quantity is used in this country, mainly in the manufacture of explosives. We are not aware that any undertaking devoted solely to the production and sale of pyrite is existent in this country, except a small venture on the Black Reef, where it is said that a few people are engaged in concentrating the pyrite in tailings and selling it at a profitable figure to the Natal Ammonium Co. A little while ago a large number of claims were pegged out in the Low Country on an extensive series of pyrite-bearing quartzite, in which the sulphide was fairly abundant. An occurrence to the west of Pretoria has recently been taken in hand, also, in the vicinity of a farm where a small galena proposition has been worked with very satisfactory results for some months past. The pyrite here is said to occur in the massive form, the vein being of the interstratified kind which is commonly found in the Transvaal System. Some 13,741 tons of Sicilian sulphur were exported to South Africa during the same year. A figure of about £2 per ton has been quoted recently as the price which local buyers are prepared to pay for clean pyrite at present. The possibilities of an industry are obviously well worth looking into.[1]

Sulphuric Acid

It is a trite saying that sulphuric acid is to the chemical manufacturer what iron is in the metallurgical world. But to the general public this saying makes no appeal, for sulphuric acid is not a final product like iron, and is only a means to an end. It is not seen in our houses and highways, and to the average person it is merely a name, sometimes not even so much as that. To mining men it is more often than not a nuisance, as for instance in the case of smelter smoke or of acid mine-waters. Being a dangerous material and not conveniently stored and transported, it is usually manufactured on the spot where it is required, and manufacture precedes consumption by as short a space of time as possible. In other words, it is made according to requirements, and there is little acid on the market. It follows therefore that if a smelter is forced by the pressure of public opinion to make acid instead of pursuing the older and more

[1] *So. Afr. Min. Jour.*, Oct. 23, 1915.

convenient way of discharging the acid gases and vapors into the atmosphere, he is faced by a very real difficulty as regards the disposal of his by-product. He can rarely find a ready market for it, and has to create one by establishing a business that requires it as raw material. But if he can not sell his acid or use it in the manufacture of some more saleable article, he is in a serious quandary. The producer *malgre lui* is therefore in a difficult case. On the other hand, a consumer who suddenly wants an increased supply is in almost as bad a position, and his contemplated expansion of operations may be blocked for months. This feature of the trade is well exemplified by the large requirements of sulphuric acid needed for the manufacture of high explosives, on a stupendous and unprecedented scale, for the purposes of the present war. The shortness of shells and ammunition for the British army was due in large part to the difficulty of increasing the usual acid supply a hundred fold. While new factories were being built, the uttermost parts of the earth were scoured for ready supplies. Some was secured in the United States, and its shipment gave an instance of the difficulties of transport to which we have referred, for many of the containing vessels came to grief and did damage to the ships carrying them and to the other parts of the cargo.

Sulphuric acid has so many large industrial applications that we can not do more than indicate a few of them. The first of the big uses was the manufacture of soda products from salt by the Leblanc process, and consequently the acid works are usually found at the centers of alkali manufacture. Of recent years the introduction of the ammonia-soda and electrolytic processes has proportionately decreased the amount of acid used for this purpose. Similarly the amount of sulphuric acid consumed in connection with an adjunct of the Leblanc process, that is to say, the release of chlorine from bleaching powder at bleaching works, has suffered, seeing that nowadays much of the chlorine is supplied in liquid form instead of as bleaching powder; and moreover hypochlorites are used largely in bleaching, instead of free chlorine. Sulphuric acid is employed in the manufacture of most of the other acids. The list of commercially valuable salts of sulphuric acid is a long one, but we may specify as examples sulphate of ammonia and sulphate of copper. It is used in the production of soluble superphosphate from insoluble phosphate in bones and rocks, in the preparation from starchy materials of sugars used in brewing, in oil refining, in the production of aniline dyes and high explosives. All these manufactures call for large supplies of acid.

As regards the raw material from which the acid is made, Spanish pyrite still holds first place, and then comes native sulphur mined in Sicily and Louisiana. Other sulphides such as blende are employed, but usually only when the acid is a by-product. The sulphur of the pyrite in coal is also an important raw material at gas-works, where the sulphur is caught by iron oxide, which is afterward sent to the acid plant. Much sulphur is also recovered from alkali waste and thus used over again. In the old days the acid was produced by the dissociation of green vitriol, or ferrous sulphate, a source that explains the origin of the name "oil of vitriol."[1]

The most important commercial grades of acid are the 50 B. or chamber acid, containing 62.18 per cent. H_2SO_4 and having a specific gravity of 1.526; the 60 B. acid or tower acid, containing 77.67 per cent. H_2SO_4 and having a specific gravity of 1.706. This grade also includes concentrated chamber acid or lead pan acid. The 66 B. or oil of vitriol contains 93.19 per cent. H_2SO_4 and has a gravity of 1.835. Besides these are the 97 per cent. monohydrate, and fuming acids which contain from 5 to 20 per cent. of dissolved trioxide.

About five-eighths of all the acid produced is chamber acid, the most of which is used in the manufacture of fertilizers from phosphate rock, the manufacture of sulphate of ammonia in connection with the destructive distillation of coal, and the manufacture of alum. Most of the 60° acid is used in the steel industry for pickling purposes; the 66° acid is principally employed in the purification of petroleum and in the manufacture of mixed acid in the explosives industry, as are also the higher strengths—the 97 per cent. and the fuming—the manufacture of reclaimed rubber and the general chemical industries.

The production of acid by grades is tabulated in detail below:

PRODUCTION OF SULPHURIC ACID IN THE UNITED STATES IN 1914 AND 1915, BY GRADES IN SHORT TONS

(Figures of the U. S. Gelogical Survey)

Grade.	1914.			1915.		
	Quantity.	Value.	Price per Ton.	Quantity.	Value.	Price per Ton.
50° Baumé	1,628,402	$9,712,056	$5.96	(b)1,518,271	$10,681,246	$7.04
60° Baumé	551,955	3,376,242	6.12	657,076	4,976,453	7.57
66° Baumé	916,192	10,509,471	11.47	1,019,024	14,211,381	13.95
Other grades	65,890	882,158	13.39	(c)189,795	2,787,971	14.69
Total	3,162,439	$24,479,927	7.74	3,384,166	32,657,051	9.65
Total reduced to 50° Baumé acid	(a)3,762,417	(a)24,163,331	$6.42	3,868,152	29,869,080	7.72

(a) Exclusive of 21,993 short tons of fuming acid, valued at $316,596. (b) Includes acid reported not only at 50°, but also as 52°, 53°, and 55°. (c) Includes stronger acid reported as oleum, etc., carrying varying percentages of free SO_3.

[1] *Min. Mag.*, Dec. 15, 1915.

PRODUCTION OF SULPHURIC ACID FROM COPPER AND ZINC SMELTERS, 1912–1915, IN SHORT TONS
(Figures of the U. S. Geological Survey)

Source.	60° Baumé Acid.								
	1912.			1913.			1914.		
	Quantity.	Value.	Price per Ton.	Quantity.	Value.	Price per Ton.	Quantity.	Value.	Price per Ton.
Copper smelters..	(*b*)321,156	*b*) $1,985,704	(*b*)$6.18	336,019	$2,205,627	$6.56	348,727	$2,215,690	$6.35
Zinc smelters....	(*b*)292,917	(*b*) 2,255,237	(*b*) 7.70	296,218	2,140,645	7.23	411,911	2,974,603	7.22
Total.......	(*b*)614,073	*b*) $4,240,941	(*b*)$6.91	632,237	$4,345,272	$6.87	760,638	$5,190,293	$6.82
Total acid reducted to 50° Baumé.	(*c*)764,237	....	....	790,296	....	.....	950,798	....	.....

Source.	1915.	Quantity.	Value.	Price per Ton.
Copper smelters, 60°..................	....	360,522	$2,749,633	$7.63
Zinc smelters, 60°......................	....	484,942	4,292,493	8.85
Other strengths........................	....	59,189	579,115	9.78
Total............................	....	904,653	7,621,241	8.42
60° acid reduced to 50° Baumé.........	....	1,056,830	....	....

(*a*) The acid reported to the Survey includes that of strength of 50°, 53°, 60°, and 66° Baumé, and a small quantity of electrolyte and oleum. All strengths, with the exception of the electrolyte, have been reduced to both 50° and 60° Baumé, as given in the table.
(*b*) Inclusive of a small quantity of electrolyte.
(*c*) Exclusive of a small quantity of electrolyte.

The sulphuric acid industry in the United States in 1915 presented both remarkable and normal features. In spite of the abnormal demand, a great deal of sulphuric acid was consumed in the factories where it was made. The trade in strong acids was much more active on account of the demand for explosives and other war munitions, but this demand came only after the first quarter of the year and was very strong only during the last 6 months. Before that time some acid plants were shut down.

The production of sulphuric acid of 50°, 60° and 66° strengths in 1915 was 3,868,152 tons expressed in terms of 50° acid valued at $29,869,-080. In addition there was a production of 189,795 tons of fuming acid and oleum valued at $2,787,971. This is an increase of 3.5 per cent. in the three common grades, but the production of fuming acid and oleum increased to over eight times the 1914 figure. These figures include by-product acid produced at copper and zinc smelters amounting to 1,056,830 short tons of 50° acid. Compared with the production of 1914 this is an increase of 11 per cent. or 106,032 tons. The prices per ton of the stronger grades of acid, especially 60°, 66° and oleum during the last part of the year ranged far above those of 1914, and the total value of the output will therefore be in excess of what it was for that year.

An index of the development of chemical and metallurgical industry in Utah is found in the announcement by C. W. Whitley, general manager for the Utah department of the American Smelting & Refining Co., that his concern will shortly erect in the Salt Lake valley a sulphuric acid plant. It is reported that the manufacture of acid will be in conjunction with the smelting operations of the company, utilizing the sulphurous smelter gases. If the company's experiments in zinc hydrometallurgy with electrolytic deposition prove successful enough to warrant the construction of a commercial plant, much of the sulphuric acid produced will be used in the treatment of zinc ores.[1]

Exports.—Exports of sulphuric acid in 1915 were 77,812,029 lb., the largest on record. The total for 1914 and 1913 was 13,176,175 lb. and 9,689,005 lb. respectively. For the fiscal year of 1910 the total exports were only 5,081,038 lb. and in that of 1914 they were 12,131,750 lb.

Before the war 60° sulphuric acid sold at about $10.50 to $11 per ton in tank-car lots with $12 to $13 obtained for 66° acid. While as high as $110 is said to have been received for tank-car lots, some makers are now selling regularly at $40 to $45 for 60° acid in tank-car lots. Another producer is understood to be obtaining $75 per ton in tank-car lots and $80 per ton for acid in carboys for 66° acid. Commercial acid obtained as a by-product in zinc smelting is reported to be sold at $24 to $30 per ton.[2]

Nearly 3000 tons of sulphuric acid for making high explosives for use by the Allies is being shipped from Savannah every month to the du Pont Powder Works at Wilmington, and other manufacturers by Phosphate Mining Co., of Savannah.

This company has a contract with du Pont Co. that calls for nearly 150 tons monthly, and contracts with other companies fully as large. Officials state that contracts are good practically as long as the war lasts.

The sale of Anaconda's surplus output of sulphuric acid to du Pont interests is an unimportant transaction, so far as Anaconda is concerned. The bulk of output, about ·125 tons a day, is used in its own plants. There was a small accumulation on hand, and this was sold. No firm contracts have been entered into for sale of this surplus product.[3]

Foreign Supplies

France.—The requirements of the French munition factories for sulphuric acid have become so important that it has been questioned whether the whole of the French output should not be reserved for the

[1] *Met. Chem. Eng.*, Feb. 1, 1916.
[2] *Min. Eng. World*, Mar. 18, 1916.
[3] *Min. Eng. World.*, Jan. 22, 1916.

state instead of the 20 per cent. as at present. Happily it has been remembered in time that the needs of agriculture are as important as others from the point of view of the war, and it has been finally decided to reserve the quantities necessary for the manufacture of superphosphate.

It is estimated that this will give from 300,000 to 400,000 tons of superphosphate—little enough in comparison with the amount used before the war, but now perhaps sufficient in view of the shortage of labor in the country districts.[1]

Great Britain.—Everywhere in England it is complained that the color difficulty grows greater, and the government consumption of sulphuric acid is freely given as the cause of the shortness of the supply of British-made colors. Dyers feel the shortage more acutely than anybody else, but the consequences are felt, of course, by everybody needing colored yarn or goods, so that there is a continual buzz of dissatisfaction. It may be hoped impartially that the arrangements for promoting the production of sulphuric acid are upon a scale commensurate with the new arrangements that are being made for its consumption. Very soon sulphuric acid will be wanted in quantities largely exceeding a consumption that is already tremendous, and a surplus beyond the needs of the explosives trade is indispensable if there are to be dyes in any abundance.[1]

Russia.[2]—During 1915 the Russian sulphuric acid business experienced very difficult conditions. The raw material for the production of the acid, and particularly sulphur ore, previous to the war was obtained from abroad to the extent of about three-quarters of the quantity required and only those factories in the east of the Moscow margin used Russian, usually Ural, pyrite. In addition to this the production of sulphuric acid takes place mostly in the western parts of European Russia, in some way or other having been affected by the military operations, so the seriousness of the question of supplying the industry, whether on behalf of the national defence or for private requirements can hardly be overestimated.

Technology

A new method of manufacturing sulphuric acid, for which advantages are claimed, is suggested in United States Department of Agriculture *Bulletin* No. 283, "The Production of Sulphuric Acid and a Proposed New Method of Manufacture." The essential difference of the method is that the gases employed are drawn downward through a spiral flue in place of being drawn through lead chambers or intermediate towers. It is asserted that the resistance of gases to the downward pull and the constant change in their course through the spiral tend to mix them very

[1] *Eng. Min. Jour.*, December, 1915.
[2] *Chem. Trade Jour.*, Apr. 1, 1916.

intimately. The fact that the gases constantly impinge on the walls of the spiral flue, which can be cooled either by air or water, makes it practicable to maintain the gases at a temperature most favorable for the efficient yield of sulphuric acid.

In laboratory tests in which the spiral was utilized practically all the sulphur dioxide was oxidized to sulphuric acid, only traces being lost through escape or in the system. The lead spiral, the author points out, however, is not intended to replace the Glover tower, nor to do away with the Gay-Lussac tower.

It is believed that while the lead spiral will take considerable lead, the great reduction it will effect in the chamber space will make it possible to construct a plant with considerably less lead than is required in the ordinary chamber system.

The new type of plant requires no other device to accelerate the reactions, occupies much less ground space, and would not need as large buildings, and therefore should decrease the initial cost of construction. The method, however, has been tried only on a laboratory scale, and the bulletin refuses to predict just how efficient the commercial plant would be, but states that all indications are that this method offers promise of being economically successful.[1]

New Use.—At one of the sessions of the recent San Francisco meeting of the American Institute of Mining Engineers, Dr. Lippman explained the nature and results of his investigations, and illustrated by photographs the apparent beneficial results obtained by applications of sulphuric acid to alkali soils. The views showed crops growing on test plots that had received from 2½ to 7½ tons sulphuric acid per acre, the ground being otherwise unfit for agricultural purposes on account of the concentration of alkali salts. One effect of the acid is to cause a shrinkage of the colloids, giving a better opportunity for aeration of the soil and circulation of moisture, and creating more favorable conditions for the activity of nitrifying bacteria.

An important feature of the work from the metallurgical standpoint is the quantity of acid used, running into tons per acre. From the agricultural side there is prospect of rendering useful a vast acreage of ground in the Western States, now lying waste and shunned by the farmer. Here is prospect of coöperation for mutual good between interests that have regarded each other with suspicion and enmity.[2]

Sulphuric Acid Substitutes[3]

A small committee of users of sulphuric acid in the Yorkshire, West Riding, England, along with a representative of the Ministry of Muni-

[1] *Comm. Rept.*, Sept. 22, 1915.
[2] *Met. Chem. Eng.*, Oct. 1, 1915.
[3] *Chem. Trade Jour.*, Jan. 8, 1916.

tions and officials of the West Riding of Yorkshire Rivers Board, have been considering how to overcome the difficulty in which they are placed by the scarcity of sulphuric acid. The conclusions arrived at are the subject of the following report made by the Secretary to the Committee:

For some time past the supply of sulphuric acid has fallen much below the demand, and recently the Ministry of Munitions have made it known that they will require greatly increased amounts for the manufacture of explosives, so that the supply for ordinary manufacturing purposes will shortly be still more reduced. It is necessary, therefore, to inquire whether any substitutes can be obtained, and such a substitute there is in niter cake, a by-product from the manufacture of nitric and sulphuric acids.

Niter cake is produced at present in such enormous quantities that some makers have been compelled at great expense to find spoil heaps upon which to deposit it or to carry it out to sea and dump it there. This is an extremely wasteful proceeding, inasmuch as the cake contains the equivalent of some 30 per cent. of pure sulphuric acid, which is quite available for many of the processes in which sulphuric acid is used in ordinary times. Experiments in the use of niter cake have been carried out at a number of mills in the West Riding in connection with the various operations in which sulphuric acid is ordinarily used: (*a*) For the extraction of grease from piece-scouring suds. (*b*) For the extraction of grease from wool suds. (*c*) For the refining of grease. (*d*) For stripping color from rags in the making of shoddy. (*e*) For extracting cotton from mixed fabrics in the shoddy trade. (*f*) For dyeing rags in the shoddy trade.

From the results of these experiments, which have all been on a working scale, it is evident that niter cake can be used in place of ordinary sulphuric acid for the extraction of grease, either from wool suds or piece-scouring suds, for the refining of grease, for the stripping of rags except for perhaps where light dyes are to be subsequently used, and for dyeing rags in the shoddy trade, more especially where dark colors are being used.

In using the niter cake for extracting cotton from rags, grave difficulties have presented themselves, but even in this case it would appear that niter cake can be to some extent substituted for sulphuric acid. The use of niter cake presents certain difficulties, but these for the most part can be surmounted.

1. It is more difficult to handle than acid, since it is in the form of solid cake, and must be used in larger quantities, as it contains only 30 per cent. of its weight of pure sulphuric acid, compared with the 75–80 per cent. present in acid.

2. In carriage, storage, and handling, the acid liquid draining from it causes damage which may be serious.

3. The great difficulty, however, is that of transporting it either by railway or by road, and this is enhanced by the greater amounts necessary.

The best method of using the cake is to dissolve it in hot water by the aid of steam, and to use this solution while still hot. The solution in an equal weight of water usually contains one-sixth of the sulphuric acid, and therefore must be used in quantities about six times greater than when acid is used.

The cake can be stored with safety by placing it under cover on an asphalted floor, or on a stone floor the joints of which are sealed with asphalt, drained to a catch-pit, where any acid can be caught for use. Care should be taken that the acid draining away is not allowed to penetrate into the soil near any buildings. It is desirable to have as little handling of the cake as possible, as it is as dangerous a substance as ordinary acid, and the men working with it should have their clothes protected by sacking, and should be provided with oil or grease to protect their hands.

The chief difficulty to be met is that of railway carriage and cartage, and if niter cake is to be generally used in place of acid, very large quantities will have to be conveyed by rail and road. In this direction the assistance of the Ministry of Munitions has been asked. It is suggested that arrangements should, if possible, be made for depots to be established at certain centers, *e.g.*, Bradford, Dewsbury, Huddersfield, Keighley, Leeds, and Wakefield, at which the cake may be dumped in large quantities and from which it may be distributed by carts or motor trucks. To such depots regular trains could be kept running from the producing centers.

The difficulty of local cartage is as great as that of carriage by railway, and the Ministry have been asked to consider the question of making some arrangements for securing the necessary supply of carts and motor trucks. It is necessary to point out that the introduction of niter cake, if it is to be substituted for sulphuric acid on a large scale, will entail a sudden and great disorganization of many of the operations in the woolen trade and several trades in the West Riding are equally concerned. It is suggested, therefore, that to deal with the various difficulties which must arise, a large and representative committee should be formed by the Ministry, consisting of users of sulphuric acid in the West Riding.

A representative committee of this kind would be found useful in disseminating information, in helping the manufacturers to use niter cakes to the best advantage and in advising the Ministry of Munitions on any difficulties which may arise, especially in regard to the proper distribution of niter cake and of the sulphuric acid that may be available.

To prevent manufacturers of niter cake unduly inflating prices, the Ministry have arranged to dispose of a very large amount produced at His Majesty's factories at Queensferry, Cheshire, at Oldbury, and at Gorton Brook, free on rail or at a nominal charge and as other huge amounts are produced at factories in the neighborhood of the Thames, where the niter cake is at present disposed of at considerable cost, it is possible that further arrangements of this nature can be made, and that in these cases, the manufacturers or the Ministry may be induced to pay part of the cost of the carriage.

The matter is one which interests the Rivers Board very closely, inasmuch as the suds from piece scouring and wool washing are required to be treated with acid for their purification, and the Board have instructed their officials to give any information in their possession to any of the manufacturers who may desire to make use of niter cake, or who meet with any difficulties in its use.

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TALC AND SOAPSTONE

By Frederick B. Peck

By virtue of its peculiar properties talc has proven useful for so many purposes that it may be listed among the indispensable mineral products of the civilized world. It has no equal as a "filler" for all kinds of paper, in which capacity alone it supplies a universal need in our modern economy of nations.

In 1915 the United States marketed 166,336 short tons of talc, which was valued at $1,401,197, an increase of 15,248 tons over the marketed production of 1914.

The production of soapstone in the United States for 1915 was 20,555 tons, 97 per cent. of its production for 1914. The combined production of talc and soapstone in 1915 exceeded the 1914 production by 14,595 tons, due to the heavy increase in talc.

Massachusetts, New York, Pennsylvania, New Jersey, Georgia, and California produce talc alone. Rhode Island and Maryland produce soapstone only. Vermont, Virginia and North Carolina produce both talc and soapstone. In the production of talc New York leads with over one-half (57 per cent. in 1914) of the total output of this country, followed by Vermont which with its recent greatly increased production, now produces more than one-half as much as New York. Pennsylvania and New Jersey have for many years been steady producers of a rock which is ground and sold as mineral pulp. The quarries which produce the rock are located on opposite sides of the Delaware River, near Easton, Pa. A part of the rock quarried is true talc, but much of it is serpentine and partly decomposed tremolite. Formerly a considerable amount of the serpentine was quarried and sawn into slabs and polished for decorative purposes, but the rock occurs in limited quantities and is of such a variable character as to make it difficult to furnish large orders of a uniform character, so that what promised at one time to be a flourishing industry has proved to be somewhat disappointing. The largest quarry of the region, owned by C. K. Williams & Co., paint manufacturers, is located just above Easton on the Pennsylvania side of the river, from which a considerable tonnage of rock is taken and ground to a pulp, which is used in the manufacture of mineral paint. The bulk of the rock from this quarry is a partly altered tremolite with some serpentine. In places it consists of a fine aggregate of brown (phlogopite) mica, altered more or less, completely to talc. The tremolite rock, however, predominates.

Below is given in tabular form the amount of talc and soapstone produced by the various States for the past few years, with the value of the production.

PRODUCTION OF TALC AND SOAPSTONE BY STATES

	1910		1911.		1912.		1913.		1914.	
	Tons.	Value.	Tons.	value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
New York.....	71,710	$728,180	62,030	$613,286	66,867	$656,270	81,705	$788,500	86,075	$821,286
Vermont.......	25,975	136,674	29,488	200,015	42,413	275,679	45,547	327,375	50,689	363,465
New Jersey and Pennsylvania	13,192	62,833	12,131	54,319	10,400	50,519	11,308	80,780	7,732	54,549
Virginia........	25,908	519,781	26,759	660,926	25,313	576,473	26,487	615,558	21,687	527,938
Massachusetts..	7,475	52,204	7,642	36,883	....	....	....	....	....	....
NorthCarolina .	3,887	69,805	3,548	57,101	3,542	63,304	4,676	48,817	1,198	28,413
California......	......	....	......	....	1,169	15,653	952	6,000	547	8,786
Other States...	......	....	......	....	9,566	69,065	5,158	41,067	4,359	60,650
Total.......	......	....	......	....	159,270	1,706,963	175,833	1,908,097	172,286	1,865,087

Talc only..................................	California and New York.
Talc and soapstone.........................	North California, Vermond and Virginia.
Soapstone only.............................	Rhode Island.
Talc and serpentine........................	New Jersey and Pennsylvania.
Pyprophylite...............................	North Carolna.

The United States is so far in the lead of other nations in the production of talc and soapstone as to be without a close competition. France held second place until the outbreak of the war and produced about one-fourth the amount of the United States. The French manufactured talc or steatite, sells under the name of "French chalk." With chalk proper, it has no chemical resemblance whatever, being a hydrous silicate of magnesium ($H_2Mg_3Si_4O_{12}$) while chalk is a carbonate of lime ($CaCO_3$).

It is used in large quantities for a great variety of purposes, but since the outbreak of the war its production in France has been greatly curtailed. Great Britain looked naturally to France for her supply of this article and when this source failed, she sought it elsewhere, and has found it in one of her own possessions, viz., the Barberton district of South Africa. These Barberton deposits had been known for years and had been partly developed, and the failure of the French supply was the occasion for their immediate active exploitation. Now regular shipments from South Africa to England are being made, and the result will probably be the development of another industry in that part of the world, and the addition of another name to the list of talc-producing localities. All over the world the great war has been responsible for the birth of all sorts of new concerns, and so this Barberton talc industry, too, must be reckoned among the "war babies."

The Canadian talc industry in 1915 was brisk, practically reaching its previous high water mark of 1912 with over 12,000 tons, valued at $40,-554, of which 11,885 tons were marketed. All of the Canadian talc comes from the Consular district of Kingston, Ont., from two deposits located at Madoc and Eldorado which are reported to be of good size. At Madoc the talc rock occurs as a series of overlapping lenses, of nearly vertical dip, the greatest width of which is about 60 ft. They have been mined to a depth of 250 ft. Most of the output is ground at Madoc, a small quantity being shipped crude to the United States.

The Eldorado deposits contain considerable quartz in the form of small lenses which is of course objectionable and must be cobbed out.

In 1915 Canada exported talc to the United States valued at $60,843.

The amount of talc and soapstone produced by the different producing countries is shown in the following table.

PRODUCTION OF TALC AND SOAPSTONE BY COUNTRIES
(In tons of 2000 lb.)

	U. S. (*a*)	France (*b*)	Italy (*c*)	Canada. (*c*)	Spain. (*d*)	Austria. (*c*)	Ger. Empire, Bavaria. (*d*)
1906	120,644	29,061	9,624	1,234	3,978	....	2,131
1907	139,810	38,262	13,574	1,534	....	15,294	2,203
1908	117,354	37,053	12,048	1,016	5,214	....	2,424
1909	130,338	38,433	13,228	4,350	6,154	....	2,537
1910	150,716	42,316	13,727	7,112	5,143	....	3,308
1911	143,551	44,092	15,600	7,300	6,226	15,212	3,728
1912	159,270	60,629	15,800	8,270	(*e*)	(*e*)	3,551
1913	175,833	(*e*)	23,530	12,250	(*e*)	(*e*)	(*e*)
1914	172,296	(*e*)	24,271	10,808	(*e*)	(*e*)	(*e*)
1915	186,891	(*e*)	(*e*)	11,885	(*e*)	(*e*)	(*e*)

(*a*) Talc and soapstone. (*b*) Talc, soapstone and asbestos. (*c*) Talc. (*d*) Soapstone. (*e*) Statistics not available.

TIN

By Baliol Scott

1915 marked an important stage in the development of the tin industry. Early in the year active steps were taken in the United States to profit by the closing by war of the German markets for Bolivian concentrates as well as to secure to the United States some control in the way of home reduction of at any rate a portion of her national requirements. At the same time the action of the belligerents, more especially Great Britain, in placing embargos on the free export of tin to the United States from British possessions forced an increased demand for the production of the Dutch Islands Banka, Billiton and Singkep which has resulted in a considerable direct trade being established between East Indian and United States ports. This traffic owed its rapid development in part to the difficulties of preventing tin once imported into Holland being transferred to Germany and there is no doubt that the direct outlet to America met the convenience not only of United States purchasers but also of the Dutch authorities and so indirectly the Allies themselves. What will be the future of this trade when the war is concluded we have still to discover, but the fact remains that while the rest of the world last year showed lower imports of tin, those of the United States increased very largely and fell little short of the record year, 1912. In this connection the following table of imports is of interest:

IMPORTS OF TIN INTO THE UNITED STATES

Year.	Pounds.	Value.	Year.	Pounds.	Value.	Year.	Pounds.	Value.
1904..	83,168,657	$22,356,896	1908.	82,503,190	$23,932,560	1912.	116,003,385	$50,371,102
1905..	89,227,698	26,316,023	1909.	95,350,020	27,559,937	1913.	104,282,230	46,900,314
1906..	101,027,188	37,446,508	1910.	105,137,740	33,921,449	1914.	95,049,612	32,861,188
1907..	82,548,838	32,075,091	1911.	106,936,872	43,390,639	1915.	115,636,332	38,736,909

At the same time contracts were negotiated in Bolivia for the supply of a certain quantity of ore and a smelter put in hand at Perth Amboy by the American Smelting & Refining Co., with a reported capacity of 5000 tons of metal which it put in operation early in 1916. The closing of the Panama canal, however, necessitated considerable delay in the shipment of ores but the smelter was reported to be delivering metal about the beginning of April. More detailed reference to the matter is made under the section of Bolivia. In addition to this enterprise which is of the standard type of reverberatory and shaft furnace associated with subsequent electrolytic refining, there has been a great deal of talk and some experiment with electric furnaces. The writer, however, is unable to learn whether any production on a commercial scale was being undertaken up to a recent date. Various accounts are current of the experimental work done in England with the Ruthenburg furnace on Cornish ores some few years ago. Commercial opinion, finding no attempt to establish the process on a working scale, has drawn adverse inferences, but the impression apparently exists in America that this is not the reason for the failure to carry operations to a practical stage.

The Tin Market

The progress of 1915 showed, as was natural, an increasing independence in America of the London market. For this the policy of the British Government was in part responsible in so far as the fear was created among American consumers that supplies might be at any time cut off for an unknown period. As the year advanced and the certainty of great activity in the home trade became assured large forward buying appears to have been entered into by American consumers and in October and November sensational rumors went around the American trade as to an intention to impose an export duty on metal from the Straits and later on that the Suez Canal was to be closed. In view of subsequent developments it would certainly seem that these reports, which were unfounded, were connected with market operations. In most cases prices for spot commanded sharp premiums over future dates and the extent of the fluctuations caused considerable comment among consumers. The monthly average prices of tin in New York and London are given by *The Engineering and Mining Journal* as follows:

MONTHLY AVERAGE PRICES OF TIN IN 1913, 1914, AND 1915

Month.	New York.			London.		
	1913.	1914.	1915.	1913.	1914.	1915.
January	50.298	37.779	34.260	238.273	171.905	156.550
February	48.766	39.830	37.415	220.140	181.556	176.925
March	46.832	38.038	48.426	213.615	173.619	180.141
April	49.115	36.154	47.884	224.159	163.963	166.225
May	49.038	33.360	38.790	224.143	150.702	162.675
June	44.820	30.577	40.288	207.208	138.321	167.636
July	40.260	31.707	37.423	183.511	142.517	167.080
August	41.582	*	34.389	188.731	*	151.440
September	42.410	32.675	33.125	193.074	*	152.625
October	40.462	30.284	33.080	184.837	*	151.554
November	39.810	33.304	39.224	180.869	139.931	167.670
December	37.635	33.601	38.779	171.786	147.102	167.000
Av. year	44.252	....	38.590	206.279	....	163.960

New York in cents per pound; London in pounds sterling per long ton. * No quotations.

In London the highest price, £190 per ton, was reached during the second week in March and from that time there was a steady decline down to £149 in the second week in October. Henceforward there was a steady recovery and the year closed at £167, 15, 0 or 10s. lower than the price at which the year opened. Since the end of the year there has been a rapid rise in the price of the commodity but the large stocks existing are felt to be a source of some weakness.

World's Production and Consumption

Owing to the war it is unusually difficult to obtain statistics relative to the industry. It would seem, however, that the production last year was practically the same as in 1914. The totals compare as follows:

	1915, Tons.	1914, Tons.
Malaya	46,609	49,042
Bolivia	21,794	22,356
Banka	13,773	13,973
Siam	7,800(a)	6,800
Cornwall	5,000(a)	5,056
Billiton	4,000(a)	4,000(a)
Nigeria	4,094	4,517
China	3,012(b)	1,824(b)
Australia	2,312	1,544(b)
South Africa	2,094	2,094
Total	112,281	111,226

(a) Estimate. (b) Shipments to Europe and U. S. A.

Consumption is of course a somewhat unknown quantity owing to the war. Deliveries to the United States are put at 48,750 long tons, the largest since the record year of 1912, which only exceeded this total by 750 tons. The net imports of tin into the United Kingdom were 28,239 tons as compared with 16,198 tons in the previous year and 24,688 tons in the last normal year of 1913. The average consumption in Great Britain for 6 years previous to 1913 is round about 20,000 tons and with the considerable reduction in the tinplate industry since the war began, actual consumption can hardly be above that figure. It is therefore clear that in part the depletion of stocks caused by the interference with shipments in the latter part of 1914 has been made good, but that in addition there has been an increase in the visible supply in Great Britain.[1] In addition there has been accumulated a large supply of unsmelted ore at Liverpool, estimated at the end of 1915 at 12,000 tons. As tin is not a "war" metal and the armies on the Continent are being fed mainly with fresh provisions everything points to the consumption of tin in Europe being below that of peace time. The probabilities are, therefore, that the great increase in the American consumption has certainly no more than made good the decrease in other directions and that as production has not declined the supplies of metal are quite adequate for the world's requirements.

[1] On May 1, 1916, the visible supplies had grown to 21,287 tons.

Tin in the United States

The encouragement which has been given by the war to the prosecution of the study of the natural resources of the United States has had its effect on prospecting for tin, which has been carried out with more than usual vigor and has led to attempts being made to enlist Government support in the hope that at length the one important industrial metal which is lacking in the national armory may be supplied. However, the propinquity of Bolivia, the second tin producer in the world, has diverted attention to some extent to schemes looking to acquirement of a control of the industry in that country.

Sensible progress is reported from Alaska where the output in 1915 reached 200 tons of concentrates. The production at present is entirely from alluvial and is mainly the result of dredge work. Two dredges were operated on Buck Creek, two on Anikovik River while work was also done in the Hot Springs district on the Lower Tanana. Other States in which work is advised are South Dakota and North Carolina. However, the remembrance of Harney Peak dies slowly. No doubt the establishment of smelters in the United States will have the result of stimulating the search for ore. Deposits whether of economic importance or not certainly exist in Continental Mexico, while in Baja California there are traditions of important deposits.

Tin in Foreign Countries

Australia.—Little data are as yet available in regard to Australia. As shown above the shipments to Europe and the United States were only 2312 tons. The value of the tin raised in New South Wales was £266,780—£350 less than in 1914. The output of Tasmania was 2599 tons against 2527 tons of concentrates in 1914. The Mt. Bischoff paid no dividend last year. The ore reserves of the company are the subject of present investigation and the small output of last year appears to reflect more than mere labor difficulty. In Queensland the output was 2039 tons of concentrates against 2085 tons in 1914.

Belgian Congo.—The future of the tin deposits of Belgian Congo is more uncertain than was the case some 2 or 3 years ago. The well-known difficulties of operating in an area subject to sleeping sickness is always an impediment to any scheme and with the setback which the country has experienced owing to the temporary destruction of Belgium as a State and the fighting which has taken place against the enemy in Africa itself the prospect of these deposits being opened up is indefinitely postponed.

Bolivia.—Bolivia has received a greatly increased amount of attention in the past year through the advent of American capitalists in need of supplies of ore for the important schemes of smelting tin which took shape largely owing to the war. Bolivia felt the effect of the tin crisis at the end of 1914 severely but the miners were soon assisted by the great decline in the currency which brought the Boliviano down to about 28 cts. As a result the export last year increased by 1238 tons to 23,587 tons which though considerably below the record figures of 1913 is in excess of any other year. The result was the more remarkable in that the enormous profits offered by antimony drew away a certain amount of the limited labor force and though no doubt Chile was in a position to supply some labor owing to the crisis in the nitrate trade, such workers are not well suited to the exceptional climatic conditions of Bolivia. The improvement is no doubt due largely to the installation in more

EXPORTATION OF TIN ORE FROM BOLIVIA
(In metric tons)

Year.	*Barrilla.* Tons.	Tin Contents. (*a*)	Year.	*Barrilla.* Tons.	Tin Contents. (*a*)	Year.	*Barrilla.* Tons.	Tin Contents. (*a*)
1901..	21,573	12,943	1907.	27,678	16,607	1913...	44,594	26,756
1902..	17,340	10,404	1908.	29,938	17,963	1914...	37,259	22,355
1903..	21,785	13,071	1909.	35,566	21,340	1915...	36,324	21,794
1904..	20,369	12,221	1910.	38,548	23,129	....	....	....
1905..	27,690	16,614	1911.	37,073	22,434	....	....	....
1906..	29,370	17,624	1912.	38,378	23,027	....	....	....

(*a*) Tin content of the barrilla (black tin concentrate), computing the latter at 60 per cent. metallic tin.

recent years of extensive mechanical plant. Shipments from Pacific ports, as compiled by Mr. G. A. Witt, are estimated for 1915 at the equivalent of 21,139 tons of metal. They are chiefly interesting as showing the direct shipments to New York which amounted to 1390 tons of barilla and these have been continued on an increasing scale during the current year, the shipments up to the end of March amounting to 1620 tons of barilla. At the beginning of the year the reduction of operations by several companies owing to the loss of market induced American offers for the purchase of concentrates. An attempt was made to obtain support for sales of 1000 tons per month. Sufficient support, however, was not forthcoming. Later on, however, as both the Bolivian Government and that of the United States were anxious to forward matters arrangements were made between representatives of the American Smelting & Refining Co. and the Chilean companies, the Cia. Estañifera de Llallagua and the Cia. Minera de Oruro, by which it is believed that some 750 tons of concentrates will be available for shipment per month. The chief producer, Señor Patiño, is understood so far not to have entered into any permanent arrangements for the disposal of his ores, which previous to the war mainly went to Germany. Other and more complicated projects for the establishment of electric smelters in Bolivia itself have been urged on the Bolivian Government by two groups of American capitalists in competition with one another. Messrs. Berry and Lutweiler, on behalf of Virginian interests offered to erect tin smelters on condition of being granted a 25-year contract for the whole output of the republic. This proposition had the direct opposition of the South American Electric Smelting Co. which represented interests which had been working the Wile Electric Furnace and they were apparently willing to install furnaces without any demand for exclusive privileges. According to reports steps are being taken to proceed with this scheme and there are reports also of an electric smelter to be erected at Arica on the Coast. There can be little doubt, however, that the most important question is to secure ore contracts and the difficulties of establishing any smelting industry in Bolivia itself are illustrated by the abandonment of regular smelting operations by Sr. Luis Soux who used to turn out a certain amount of impure tin bars in Potosi. Since the completion of the railway to that district, however, it has been found more profitable to ship most of the concentrates to Europe.[1]

One of the difficulties which any enterprise which contemplates the smelting of Bolivian ores on a large scale has to consider is the obtaining of satisfactory supplies of ore for admixture to overcome the foulness of the Bolivian concentrates. Some time before the war attempts were made in the United States to arrange a combine of Nigerian producers to sell their ores to the United States. The matter was not an easy one to arrange and after the war broke out the British Government forbade the export of these ores to foreign countries and it seems to be recognized in the United States that for the present at any rate any home enterprise must be handicapped in this respect so much so that the American Smelting & Refining plans are for the electrolytic refining of the output from their smelter. Apart from such a further stage of reduction the metal would no doubt have to sell at a considerably lower price than that from the British or Dutch tin houses. However, the United States undertakings can possibly count on tariff assistance as soon as they establish an output of substantial proportions. Figures are published of experimental runs with the Wile Electric Furnace on concentrates of the following analysis: Tin, 66.96; iron, 0.92; sulphur, 1.14; silica, 5.25 and antimony, 0.42. The furnace produced tin of 98.75 per cent. purity direct without refining. The balance consisted of 0.69 per cent. of antimony and the residue iron. The loss of tin in the

[1] *Min. Eng. World*, Apr. 3, 1915, p. 643.

slag was 1.89 per cent., and the power expended 450 kw.-hr. per ton.[1] Descriptive articles of some of the mining districts have appeared in the American mining press. Mr. F. C. Lincoln has dealt with Potosi, Milluni and Quimsa Cruz in articles in the *Mining and Scientific Press.*[2]

The Quimsa Cruz district is of interest as it was there that the International Tin Co. at one time hoped to find the ore which it was unable to obtain for its Bayonne smelter from Malaya. Mr. Lincoln gives the all-in cost of producing a ton of tin at $290 as an average for the district. In the case of the Milluni mines he puts it at $268. These figures are certainly below what is generally assumed to be the cost of production for ordinary Bolivian properties.[3] The tin dressing practice at Llallagua is described by Durward Copeland and Scovill E. Hollister.[4]

Operations in Individual Districts by Benjamin L. Miller and Joseph T. Singewald, Jr. Huayni-Potosi.—During 1915 Huet Brothers were actively engaged in mining at several points about 25 kilometers north of La Paz near the foot of Mt. Huayni-Potosi. At Milluni they were operating in a series of approximately parallel ore-bodies, some of which were quartz-pyrite-cassiterite veins, others were sphalerite-siderite-quartz-cassiterite veins rich in silver, and still others shattered zones in which quartz, pyrite, and cassiterite had been deposited in the spaces between the shattered rock fragments. The veins are all narrow and the mining primitive. From some of the mines the ore is carried out in cow-hide bags by Indian boys and women. From the mine openings on the steep slopes the ore in leather pouches is transported to the mill by means of a wire tram.

The Carmen mine located near La Union mill was most actively worked during the year, mainly on account of the native bismuth and bismuthinite which the tin ore contains, although the tin barrilla shipped from this mine was also considerable.

Although the firm of Huet Brothers have a great number of promising small mines in the region most of them are imperfectly developed, probably due mainly to the fact that the senior member was absent serving in the French army. The district is also handicapped by the lack of railway facilities.

The Vilaque tin placer deposits in the same region, owned by English capital, were idle during 1915. The company sent a representative out from England to re-examine the property and plan for its development.

[1] *Min. Eng. World*, Apr. 3, 1915, p. 643.
[2] *Min. Sci. Press*, Mar. 27, May 8, July 24.
[3] Compare *Min. Jour.*, June 6, 1908, p. 694.
[4] *Eng. Min. Jour.*, Sept. 18, Sept. 25, Oct. 2.

Oruro.—In the Oruro district two companies, the Compania Minera de Oruro and the San Jose Company, continued to operate. The former company has been greatly extending its operations and during the past 6 years has paid off its indebtedness, installed new machinery, built a new mill at Machacamarca, 24 kilometers south of Oruro and paid substantial dividends. Although the company has considerable reserve oxidized ores they have been sinking deeper in the sulphide ore-bodies until now the mine is the second deepest mine in Bolivia, the deepest being the Pulucayo.

The ores contain considerable silver which adds much to their value. In the mine the ore is broken in overhead stopes by means of hand drills during the day when the power, furnished by Diesel engines, is needed for hoisting, while electric drills are used at night. The broken ore is trammed to the shafts by hand and hoisted to the surface in cars, buckets, or cow-hide bags. At the surface Cholo women break the ore and sort it into three piles, the barren pyrite which is discarded, the very high-grade ore, "guia," which is shipped direct, and the medium grade ore which is transported by aerial tram to the cars in Oruro for shipment to the mill at Machacamarca. At the mill the ore is roasted with salts and then leached to obtain the silver and the residue crushed and treated by jigs and tables. More than one-half of the tin is recovered by the jigs, which make a 70 per cent. barrilla product.

Unica.—The Salvadora mine at Uncia was operated extensively during 1915 and many improvements made in both mine and mill, particularly the mill. This mine continues to hold its place as the largest and richest tin mine in Bolivia.

The Llallagua mine is on the opposite side of the mountain from the Salvadora and, in part, the two companies are working the same veins. The warfare between these two companies which continued for several years has ended and they are coöperating in the construction of a deep tunnel more than 2 kilometers in length which will drain the deeper levels of the two mines. The ore from the Salvadora mine is sorted by Cholo women who pick out the high grade ore for direct shipment. During 1915 the company shipped about 50 tons of guia monthly and about 900 tons of barrilla. When the new mill is completed the company hopes to produce 1200 to 1500 tons of concentrates a month.

The railroad which Patiño has been building was operated during 1915 to within 30 kilometers of Uncia and part of the remaining distance the grading has been completed. The war interfered with its completion. At present all supplies must be brought in and the barrilla taken out on the back of llamas. It costs about $9.00 a ton to transport the barrilla from the mine to the railroad.

Considerable work was done on the placer tin deposits below the towns of Uncia and Llallagua during 1915, with satisfactory results. The Uncia gravels are very thick, up to 90 feet, and as the cassiterite is mainly at the bottom, the deposit is being worked by shafts. In the main, the cassiterite pebbles are coarse, many composed of practically pure cassiterite being several inches in diameter although the majority are less than 1 inch in their greatest diameter.

Huanuni.—Three years ago Simon I. Patiño bought out all the mines of Huanuni with the exception of one small one and ended the bloody fights that previously had taken place at frequent intervals between the workmen of the two rival companies. During 1915 the mines were in continuous operation but with a reduced force, while the grade of ore was considerably less than in the previous year. The average content of tin in the ore milled was about 3 per cent. but in addition there was a monthly production of 5 to 7 tons of guia containing about 65 per cent. Sn. This was sorted by Cholo women at the mouth of the mine where all the ore is dumped for sorting.

Both oxidized and sulphide ores were mined from several different veins. The principal work of the year was in the line of exploration in order to determine the extent and characteristics of the ore-bodies. The Patiño tunnel which is being driven near the base of the hill for the purpose of cutting the veins at a lower level and also to drain the mine was extended but no important veins were encountered. Some small ones were found and on one of these a winze was sunk which yielded considerable ore of average grade.

The old mill had been practically dismantled and a new one was in process of construction but not completed. Awaiting its completion, large quantities of middlings and tailings were stored awaiting further concentration.

Potosi.—During 1915 three large companies operated in the Cerro Rica de Potosi—Luis Soux, The Royal Silver Mines Co., Ltd., and Bebin Brothers. Soux is the principal operator in the region and due to the peculiar law that applies to the mines of Potosi, is rapidly gaining further control and limiting the operations of other workers. The law in question grants, through the prefect of the district, permission to start a tunnel in the hill at a point not previously worked but does not specify where the tunnel must be run except that it must not break into the workings of other miners. The hill contains a number of veins and when one company has succeeded in cutting a vein ahead of the other company the right to further work is acquired while the former company may be cut out.

During the year Soux operated through a number of tunnels at different levels and transported his own ore to his concentrating mill in the lower part of the town by means of an aerial tram. Soux's production is steadily increasing, the monthly production during 1915 amounting to about 200 tons of barrilla containing 60 per cent. Sn.

The Royal Silver Mines, Ltd., has done a minimum amount of work since the outbreak of the European war, yet the mines were in operation all year.

Bebin Brothers operated several mines on the northwest side of the mountain and transported the ore to their mill in Potosi by means of llamas.

The tin placers along the river below Potosi were actively worked. These are largely controlled by Senor Mendieta of Potosi who has concessions for the greater portion of the stream gravels to a distance of 20 kilometers below Potosi. From these he produced about 30 tons of barrilla a month during the year, somewhat less than in former years.

The Mendoza Company also operated placer mines during the year with a production of about 10 tons of barrilla a month.

Porco.—The revival of the oldest mining district in Bolivia was an item of considerable importance in Bolivian mining circles. The early Spanish worked the Porco mines for silver and paid no attention to the tin, while the present company, the Porco Tin Mines, Ltd., expect to make their greatest profit from the tin ores. The new mill, which is well equipped, is located along the line of the Potosi branch railroad, a short distance from Agua Castilla. It was completed and one-half put in operation in June, 1915. The ore is brought to the mill from the mines by means of a well-constructed aerial tram.

In the development of the mines the company has been disappointed to find that the ore averages only about 2½ per cent. Sn. On the other hand it has been proved that their ore reserves are much larger than supposed and the company is confident that they can work the mines with profit. If so, it will be the lowest grade tin mine operated in Bolivia.

China.—Figures of export from Yunnan for last year are not yet available. The industry has been described with much care and detail by Arthur J. Moore-Bennet in the *Far Eastern Review.*[1] Exports from Yunnan in 1912 were 128,289 pikuls. Only the assistance of the recently established branch of the Banque de l'Indo-Chine enabled the industry to carry on during 1914. The unsettled conditions in the west of China last year render it probable that the export did not increase. A tin refinery designed by German engineers was completed in 1912 and smelting and refining operations began in 1913. Difficulties, however, in securing ore militated against the successful working and up to the

[1] See *Min. Jour.*, Mar. 4, 1916, p. 155.

present tin smelted in the little Chinese furnaces still predominates. The metal is very impure containing about only 90 to 92 per cent. Sn. It is exported to Hong Kong where it is refined by a German concern to about 98 per cent. and usually sold there, though in some cases the product is still further refined in London. After the outbreak of war the British Government stopped the export of tin from Hong Kong for a while but later the export was allowed under permit as from other countries under the British flag. There is a small production of tin from Kwangsi, the output from which was about 210 tons in 1911. The metal is exported via Wuchow, and has an average of about 95 to 97 per cent. Sn. In dealing with the production of tin from China it must always be remembered that the bulk of it is re-imported into China from Hong Kong and that on balance the net contribution to external supplies is not more than from 2000 to 3000 tons.

Dutch East Indies.—Like so much of the East the situation in the tin-producing centers of the Dutch Islands is at the present time but little known even in Holland. There is believed to be a considerable accumulation of tin in Java as the quantities notified as sold are considerably below the normal output. The output for the working year 1915 and 1916 the writer estimates at 13,773 tons from Banka and about 4000 tons from Billiton, but no complete official figures are available nor can the Netherlands Trading Co. supply any. Under the system of rationing adopted by the Allies about 3000 tons a year are now permitted to be exported into Holland for home consumption. The stocks of Banka tin in Holland at the end of the year were down to the nominal figure of 189 tons, the large stock of 3886 tons at the end of 1914 having been disposed of to Germany in the course of 1915. The total supplies exported to that destination amounted to 5797 tons in 1915. While the figures of the tin sales at Batavia are not obtainable in Holland, the impression exists that the bulk of these supplies have been sold direct to the United States and no doubt account for the large arrivals at Pacific ports in the early part of 1916.

Malay.—The output from the Federated Malay States as indicated above showed a decline of 2433 tons. The decline is probably due to the interference with the regular stream of coolie emigration. A certain number of Chinese were repatriated in the latter months of 1914 and the unsettled conditions coupled with the somewhat low price which tin averaged during the year of a little over $80 per pikul tended to a continuance of the depletion. Restrictions on emigration were withdrawn about the middle of the year. However, as the table of monthly output given below shows, there was no noticeable recovery toward the end of the year. It must be remembered that the war has sensibly affected the cost of working and of realizing the metal and that great efforts were made to keep the mines at work in 1914 which probably leave their legacy behind in the way of depleted reserves and a certain amount of discontent among the coolies owing to wage reductions. Figures of monthly output in pikuls are as follows:

FEDERATED MALAY STATES' TIN OUTPUT

	1910. Pikuls. (*b*)	1911. Pikuls. (*b*)	1912. Pikuls. (*b*)	1913. Pikuls. (*b*)	1914. Pikuls. (*b*)	1915. Pikuls. (*a*)
January	66,277	64,333	67,566	69,232	83,711	73,834
February	64,199	53,147	72,545	64,219	59,725	63,495
March	46,850	50,132	53,698	59,842	64,508	61,374
April	60,020	54,568	67,270	68,305	68,655	60,806
May	61,935	62,868	71,849	72,563	69,471	64,225
June	62,180	64,202	59,465	67,078	72,275	68,003
July	65,350	63,799	71,175	71,318	76,985	59,540
August	70,639	68,592	74,831	77,613	60,330	67,971
September	56,324	62,862	69,133	73,574	60,869	66,051
October	60,444	68,764	65,605	74,080	65,656	63,785
November	61,771	66,334	69,087	66,790	(*d*)63,639	66,739
December	60,909	62,091	71,248	77,522	(*d*)63,206	67,220
Totals	(*c*)736,898	(*c*)741,698	(*c*)813,472	(*c*)842,136	809,630	783,043

(*a*) From *The Mining Journal.* These figures show the monthly exports of tin and tin ore (the latter being stated at its assumed metal content) upon which duty is paid to the F. M. S. Government. (*b*) 1 ton (2240 lb.) = 16.8 pikuls. (*c*) Finally revised figures. (*d*) Exclusive of Pahang, etc.

A decline was shared by all the older producers, Pahang alone showing an improvement, the exports being the highest even recorded from that State. This result was due mainly to the improved returns by the Pahang Consolidated.

PRODUCTION OF TIN BY STATES (*a*)

(In pikuls of 133⅓ lb.)

	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.
Perak	435,909	431,386	467,784	461,665	421,335	437,339	....	493,753	479,621	467,346
Selangor	268,624	273,900	282,540	266,007	240,192	231,175	....	252,765	244,665	222,298
Negri Sembilan	77,766	75,155	64,221	48,072	34,697	29,230	....	36,821	35,900	29,049
Pahang	34,488	33,195	39,520	43,144	40,674	43,054	....	58,791	63,723	66,977
Total	816,787	813,636	854,065	818,888	736,898	741,698	813,472	842,130	823,909	785,760

(*a*) Exports of tin ore, the latter being calculated to its assumed metal contents, upon which duty is paid to the F. M. S. government.

These figures correspond to the following tonnages; 1913, 50,127; 1914, 49,042; 1915, 46,766. Coincidently with this decline in output there is a corresponding falling off in the labor force employed, which totalled 225,404 in 1913, 171,689 in 1914, and 164,457 last year. The mechanical power has increased, to some extent offsetting the decline in manual labor; but there can be no doubt that the decline in output is closely connected with the diminution of the labor force employed, as has always been the case in this field, where so large a proportion of the work done is hand labor. It is interesting to notice that the proportion of output from purely Chinese mines continues to show a decline. Last year it is estimated that the proportion was 72 per cent. of the total output, compared with 76 per cent. in 1914 and a considerably higher proportion in earlier years. The great feature of the last two or three years has been the success of bucket dredging, and the declining proportion shown in the yield from purely Chinese concerns is an indication of how the introduction of suitable machinery may enable the field to develop by treating previously worked ground profitably. The average price obtained for tin locally was $78.17 a pikul or £153 4s. 3d. a ton, as compared with $73.44 a pikul, equal to £143 18s. 10d. per ton in 1914. The decline in output of 2,276 tons again testifies to the fact that around £150 per ton is a critical price for the industry. It is noticeable that the State which has chiefly suffered in respect of its native force is Selangor, where the exhaustion of the tin deposits is more advanced than elsewhere. This year we have to note a further continuance of the decline, in spite of the improved prices which have been ruling. There was a considerable increase in the horsepower employed in the mines, though probably not so great as would have been the case in peace time. The total shown was 56,197 hp., compared with 41,623 hp. in the preceding year. The chief increase was shown in hydraulic, owing to the entry of the Gopeng Consolidated plant into commission and the re-working of a steam driven electric plant in Perak was the chief cause of the improved showing for steam driven plants.

As regards dredging, seven companies were in operation, accounting in all for 38,585 pikuls. The Malayan Tin Dredging Company, with four dredges, produced 11,966 pikuls from 2,412,860 cubic yards; the Tronoh Mines, with one dredge, obtained 4,338 pikuls from 790,869 cubic yards; the Kamunting returned 8,966 pikuls from 929,000 cubic yards; and the Kampong Kamunting dredge 4,768 pikuls from 640,000 cubic yards. This latter company expects to start a second dredge in the current year. The Ipoh Tin, on a five months' run, obtained 1,751 pikuls from 30,000 cubic yards, while the Chenderiang obtained 4,248 pikuls from 754,000 cubic yards on a nine months' run. Finally, the Tekka Taiping, which ran a little over two months, obtained 1,498 pikuls from 201,500 cubic yards. These figures indicate what the grade of the re-treated ground is, and how it compares with tin dredging propositions in other parts of the world. The amount of tin handled by the European smelters was somewhat less than in 1914—even so, it amounted to considerably over 90 per cent. of the whole, a marked change from earlier years in the direction of increased European influence in the field.

The following table gives the producers in excess of 5,000 pikuls.

The ground treated is also given, to afford some data as to current values. In most cases the figures given in the report include much dead work, and in consequence the yardage is only included when it is stated to be payable wash:

Mine.	Output, Pikuls.	Ground Worked, Cu. Yds.	Labor.
*Pahang Consolidated	46,461	1,596,000†	3,974
Tronoh	26,913	1,096,334†	2,592
French Tekka	18,750	1,277,500†	936
Gopeng Consolidated	13,310	....	783
Man Fatt Kongsi	11,325	228,200	1,688
Chan Thye Lee Mines	10,746	237,610	1,480
*Rahman Tin Co	10,404	83,437	692
Sungei Besi	10,304	274,000	471
*Titi	7,544	....	975
Tan Chia Mine (Batang Kali)	6,888	360,240	1,200
Eu Tong Sen's Mine (Kampar)	6,858	285,325	490
Tekka	6,603	....	454
Tong Hong Kongsi	6,502	222,803	775
Chung Thye Thin's Mine (Tronoh)	6,379	147,245	
Rahman Hydraulic	6,026	192,000	555
Thong Heng Kongis	5,501	349,910	850
Tronoh South	5,366	123,000	560
Kinta Tin	5,353	....	520
Kramat Pulai	5,012	620,000	145

* Lode mine. † Tons.

Increased activity was shown by the smelting plants of the Straits Trading Co. and the Eastern Smelting Co. at Singapore and Penang and as the Straits shipments show they handled a considerably larger amount of ore during the year. Some of this was no doubt derived from the increased output of Siam, but it is difficult to account for the balance unless some of the Dutch material is included. The bulk of the South African ore goes to the Straits smelters but the total would seem to have been somewhat less than in 1914. The output of the Northern Territory of Australia always goes to Singapore and probably an increasing amount of the product of Queensland but these various sources hardly suffice to explain the whole of the increase. An impression further exists that some material was held back in 1914 which came forward last year. There would also appear to be at any rate a small amount of Banka tin shipped via Singapore which has been included with the Straits shipments. The main sources of the increase would seem, however, to be increased supplies of time from Siamese Malaya and from Billiton. The most important conclusion to be drawn from these considerations is that the increase in Straits shipments probably does not represent any increase in the production of black tin.

As regards the output from the various smelters exact figures of course can not be as yet ascertained. In round figures, however, the following are probably fairly close to the actual output:

Straits Trading Co.	36,000 tons
Eastern Smelting Co.	17,000 tons
Chinese smelters	13,000 tons
Total	66,000 tons

The following is a table showing the monthly Straits shipments in recent years:

STRAITS SHIPMENTS OF TIN[1]

	1911, Tons.	1912, Tons.	1913, Tons.	1914, Tons.	1915, Tons.
January	4,315	3,997	5,949	5,327	5,100
February	4,290	5,256	4,666	6,527	5,555
March	4,491	5,142	4,814	4,118	5,037
April	3,115	4,235	4,301	4,914	4,357
May	4,311	5,753	6,176	6,899	6,550
June	5,057	4,302	4,824	5,877	6,800
July	4,553	4,381	4,793	5,100	5,620
August	4,675	5,366	6,011	3,480	4,797
September	5,163	5,475	5,152	5,100	5,244
October	4,371	4,422	5,015	3,785	4,426
November	4,841	5,642	5,662	5,709	6,723
December	5,994	4,996	5,105	6,404	5,370
*Sundries	1,873	2,790	2,140	2,000	2,500
Totals	57,049	51,757	64,608	65,240	68,079

* To India and China.

Great Britain.—The Cornish mines have passed through a difficult period only partly alleviated in the case of East Pool and South Crofty by the high price obtained for wolfram. For the first time Dolcoath admits having been worked at a slight loss in the second half of 1915. The trouble in Cornwall as in so many other tin fields is that there is little or no development ahead of the mill and when a time of stress comes upon them they have little reserve power on which to draw. The condition is a heritage of the past and the mines have not been able to attain that strong position in periods of prosperity which would enable them either to build up a reserve fund or else to secure 2 or 3 years' development ahead. One effect is that the grade of ore treated shows a marked decline not due to a reduction in working costs. In 1914 Dolcoath was carefully examined by Dr. Malcolm Maclaren and though the report was not published it was generally understood that he had advised against any further sinking, a conclusion which seems confirmed by the subsequent course of action by the directors whose policy is to develop the western portion of the sett at moderate depth. At East Pool the up-to-date policy of development prospecting carried on for the last 2 years by Messrs. Bewick, Moreing & Co., has been rewarded with discoveries which may be of importance to the whole of this much worked area. The mines have suffered considerably from want of labor owing to the war and it is to be feared that unless fortune once more comes to the aid of the mines in the way of some important discoveries a reduction in the level of output will occur. In the absence of official returns the output may be estimated at 5,000 tons.

[1] *Min. Jour.*, Jan. 23, 1915.

The disorganization of the tin trade of Germany caused by the war has, of course, led to there being an excess of ore offered to the smelters and at the beginning of the year about 12,000 tons was awaiting disposal in Liverpool. This has reacted somewhat on the smelters prices offered at the ticketings and considerable interest has been manifested as to what steps would be taken here to secure the trade which has hitherto gone to Germany. It is impossible to obtain definite particulars of the extent of the effort which is being made by the English smelting houses to enlarge their output. The Government object to particulars being furnished, the concerns are private companies and owing to the intense shortage of labor and materials, programmes and their realization are very different. The writer believes that Williams, Harvey & Co. and the Cornish Tin Smelting Co. laid plans for extending their works but to what extent and how far their construction has advanced he is unaware. In addition a new smelting company, the London Tin Smelting Co., has been recently established and has been a participator in the Cornish ticketings. This concern at present, however, does not profess to be working on a large scale. Before the war the total smelter output was 22,000 tons.

Nigeria.—The output from Nigeria last year was below that for 1914. The arrivals of ore in Great Britain were equal to 4094 tons of metal compared with 4517 tons in the previous year, a decrease that is of 423 tons. There is no close Government control over the statistics of the industry and consequently any data of general application are wanting. The first detailed report by the Government Inspector of Mines covering the year 1914 was published in London in December last. The tone of the report can not be said to be very encouraging and the estimate of the Inspector of Mines that the output for 1915 would considerably exceed that for 1914 was not realized. The chief producers were as follows:

	Tons Black Tin.	+ or − on 1913.	Colored Labor.
Naraguta Tin	717	− 16	2127
Rayfield	611	+153	1069
Jos Tin	408		322
N. N. Bauchi Tin	405	+112	1214
Forum River	361	+122	844
Ropp	337		609
Anglo-Continental	272		798
Bisichi	255		419
Kaduna Syndicate	251		524
Ex-Lands Nigeria	227		538
Jantar	169		511
Naraguta Extended	151		509
Mongu	128		233
W. African Mines	124	+ 64	664
Nigerian Tin Corporation	114		455
Niger Co	112		654

With alluvial mines in regard to the reserves of which nothing is known it is quite impossible to judge how long the various individual mines will preserve their relative positions. Thus the Mongu increased its output to 400 tons in 1915 while other producers fell away. The country is not generally suitable for dredging but certain properties are adapted to its employment. The first dredge began operations in April 1914 on the Jos Tin Areas, power being obtained by the medium of a semi-Diesel engine. The latest working cost is given at 20.510d. per cu. yd. The Ropp Tin has a large dredge under erection on their property. Hydraulicking is also being undertaken by several companies. Mr. J. F. Balfour in a report to the West African Mines, Ltd., summarizes the results of 5 years work in prospecting in the territories as follows:[1]

"After 5 years' prospecting, the nature of the tin deposits in Nigeria is now fairly well known. With some few exceptions they solely consist of 'patches' of fair ground. The exceptions are deposits more or less continuous, thus constituting workable areas. In the same river or watershed, the 'patches' are usually scattered over a large area or length. Such conditions call for special treatment, both as regards methods of working and the demands made upon them by the Government. They can not be looked upon for revenue purposes in the same way as regular deposits. They call for larger rents; the cost of supervision is increased; the shifting of plants is another heavy and expensive item, and if the Government press the regulations now in force for continuous working on each mining lease it will in many cases not pay to work them. If, however, the owners decide to work them, the work will consist of the rapid winning of concentrates from the richer parts of the deposits, and abandonment as soon as the cost of winning reaches a certain figure. With the fluctuating price of tin such propositions require very careful consideration, especially under the present conditions laid down by the Government. The tin fields have now been closed for over 2 years, and this has necessarily caused a suspension of the company's activities. It is probable that some of the areas pegged by other interests in the earlier days of the field and afterward surrendered have, in many cases, not been thoroughly prospected. There are still several districts well worthy of prospecting. With our present knowledge of the deposits, methods of prospecting in use during 1910 are of very little value to-day. If the Government would assist the mining industry by opening the country to prospecting at a nominal fee, reducing rents, railway freights and royalty, and allowing large areas to be held for a reasonable time, looking to profits for its revenue, companies might be induced to come in and prospect and if the Government desires the success of the industry it is to be hoped it will act before it is too late. As matters now stand the directors must decide whether further work should be taken in hand; from what has been already stated it may be inferred that under the present conditions no particular inducement is held out to encourage prospecting." Since that time some assistance has been forthcoming from the Government in that the advance in railway rates which would have taken place under the sliding scale which is governed by the price of tin has not been enforced and since Mar. 24, a flat rate of £11 per ton has been fixed. The industry also calculates on a saving from the development of local coal deposits at Udi which it is calculated should be ultimately deliverable on the fields at 30s. per ton.

[1] *Min. Jour.*, Aug. 7, 1915, p. 572.

A feature of more than local interest has been the decision of the British Government not to permit the export of concentrates outside the British Empire. Whether this measure is merely for the duration of the war or is the extension of the principle already applied in the Malayan industry is not yet known.

South Africa.—The output of tin continues to be almost entirely confined to the Transvaal. The total output is placed at 3436 short tons of concentrates, a difference only of 6 short tons on the figures of 1914. The industry has been carried on under considerable difficulties during the year as the properties being all "outside" mines they have felt peculiarly the disorganization caused by the war and the ordinary data official and otherwise are not available.

An event of some importance for the South African tin industry may be the capture of German South-West Africa. In the Government report on the economic possibilities of this country Dr. Wagner speaks favorably of the prospects of the extension of the tin industry.[1]

Metallurgy

A great deal has been heard of improvements in tin dressing in the last 2 or 3 years and a number of very elaborate papers have been read both in London and Australia on the subject. The practical result seems to be that the industry to-day stands very much where it did some 60 years since. The question was examined and discussed by M. Moissenet between 1855 and 1860 when he estimated the losses to average about 25 per cent. The ores at that time were of much higher grade and perhaps purer than to-day and the result of much investigation leaves the conclusion that the percentage is certainly no better now. M. Moissenet's conclusion was that little improvement was to be expected from wet-dressing methods and advocated the study of heat reduction as offering greater prospect of sensible improvement and to-day we see experiments with the electric furnace which is virtually adopting the advice tendered so long ago.[2] Important papers were contributed to the Institution of Mining and Metallurgy by Messrs. Wraight and Teed and by the late J. J. Beringer for so many years the instructor in assaying in the Camborne School of Mines. These papers have done little beyond confirming the fact recognized so long ago that there is a high loss of the finer tin in the ores owing chiefly to its being floated away with the excess of water employed. The British Government has now decided to make a grant up to £5000 for the further study of this question.

[1] *Min. Jour.*, Apr. 15, 1916, p. 259.
[2] Vide *Min. Jour.*, Dec. 21, 1912, pp. 1255 and 1258.

Some interest has been created by the suggestion of Morley Martin to use roughened glass as the covering for dressing tables. Improved results are claimed with this medium but the scouring effect of the hard ore particles will probably soon wear down the artificial surface. The subject was also dealt with in a very extensive paper read by Mr. H. Herman before the Australasian Institute of Mining Engineers in 1914 when the author quoted with approval the statement that though we may hear of 90 per cent. extraction, 70 per cent. is probably much nearer the mark and in many instances probably 50 per cent. would be nearer still.

During the last year an interesting paper was read by J. H. Levings on the treatment of the stannite ore at the Oonah mine, Tasmania.[1] The experimental work was unsuccessful as the capital of the company became exhausted but as the result of the experimental work done, the author suggests the following methods as offering a satisfactory method to adopt for ores of this class: (1) A preliminary roast in mechanical furnaces in part or wholly of the stannite ore to be followed by blast-roasting; (2) smelting of the roasted product under reducing conditions, producing tin-copper alloy, and sufficient 30 per cent. matte for the next operation; (3) blowing the alloy and matte in the usual copper converter into silver-copper bullion and volatilized tin oxide, the latter to be collected in flue-chambers which should be sufficient without a bag-house; (4) reduction of the tin oxide in a reverberatory or disposal to a tin smelter.

[1] *Proc. Aust. Inst. Min. Eng.*, 1915, p. 183.

TITANIUM

By James Aston

During 1915 the American Rutile Co., produced 250 tons of rutile (titanium dioxide) worth between $25,000 and $30,000, at its plant at Roseland, Va.; the largest production to date. In 1914 the output was 98 tons.[1] The rutile carries about 95 per cent. of titanium dioxide. A considerable quantity of ilmenite (titanium-iron oxide) was produced as a by-product. For a number of years this concern has been the sole producer of rutile in this country. Attempts have been made by others to develop deposits in Hanover and Goochland Counties, Va., and near Magnet, Ark., but no commercial production has yet been made at these places.

The future possibilities of titanium and titaniferous ores are discussed by P. H. Berggeen.[2]

A recent patent for the treatment of ilmenite for recovery of the titanic oxide present is that of Pieder Farup, of Trondhjem, Norway (U. S. Pat. 1156220). He treats the finely crushed ilmenite (or titaniferous iron ore) with sulphuric acid and heats until a solid sulphate mass is produced. This mass is then still further heated to about 600° C., during which heating the titanium sulphate is decomposed, the iron sulphate remaining unchanged. During this heating the material is suitable for a catalyst for contact sulphuric-acid making. The iron sulphate is then leached out with water, leaving a residue in which the titanium is greatly concentrated.[3]

G. F. Comstock[4] discusses the effect of titanium on steel. It serves as a deoxidizer, and also has the advantageous effect of combining with nitrogen. The reactions in the order of stability are: titanium, titanium carbide, titanium nitride, titanium oxide. The carbide is about as effective as the pure metal in deoxidizing steel, and is much less expensive; the titanium-content is about 15 to 20 per cent., the rest being iron and carbon. Some metal is made by the thermit process, and the resultant product is an alloy of titanium and aluminium. The thermit alloy is preferable if freedom from carbon is necessary. For steels, however, the small amount of ferrocarbon-titanium alloy needed does not increase

[1] U. S. Geol. Surv., *Press Bull.*, Jan., 1916.
[2] *Sib. Jour. of Eng.*, Apr., 1915.
[3] *Eng. Min. Jour.*, Feb. 19, 1916.
[4] *Iron Tr. Rev.*, Aug. 26, 1915.

the carbon-content appreciably. Titanium steel, properly speaking, is not made; treated steels do not carry over 0.025 per cent. of titanium in the final product, and its influence is indirect, rather than as an alloying agent.

Titanium has been employed largely in rail steels, but its use is extending to other fields. The advantage lies in promoting soundness and lessened segregation in the steel. Successful results have been obtained from the application of titanium to steel for axles, plates and sheets, and castings. Results of tensile and endurance tests upon steel rails with and without titanium treatment, are noted in the paper.

Use of titanium in rails has fallen very markedly in the last few years. In 1915, 21,191 tons of rails were treated with titanium; the maximum tonnage was 256,759 in 1910. The chief cause of the decline is the practical elimination of Bessemer steel in heavy railroad rails, and the feeling of doubt among metallurgists as to whether titanium confers material benefits in open-hearth products, where there is a minimum opportunity for absorption of nitrogen, such as exists where the air is blown directly through the bath of metal. Annual output of titanium treated rails is as follows:

	Tons.		Tons.
1909	35,945	1913	47,655
1910	256,759	1914	23,321
1911	152,990	1915	21,191
1912	141,773		

Ferrocarbon-titanium was quoted throughout the year at 8 to 12½ cts. per pound in carload lots.

Rutile is the source of titanium for making cupro-titanium for use in brass and other copper-bearing alloys, and for making potassium titanium oxalate, used in dyeing leather and textiles. A little rutile is also used in ceramics.

A small addition of titanium has a markedly beneficial influence on the properties of aluminium bronze, an alloy of about 10 per cent. aluminium and 90 per cent. copper.[1] By its use sound castings are now made at reasonable cost. The resultant aluminium bronze has physical qualities equalling those of the phosphor and manganese bronzes, while it is 16 per cent. lighter than the former and 10 per cent. lighter than the latter. The titanium-aluminium bronze is practically non-corrodible in sea water, and is very resistant to attack of chemical liquors.

Cupro-titanium is effective in degasifying castings of copper and copper alloys.[2] Improved results are claimed with copper-titanium-magnesium alloy; a representative composition being Ti 5, Cu 93, Mg 2. The fluxing action of the magnesium and titanium oxides yields very fluid slags which are easily eliminated from the bath.

[1] *Met. Chem. Eng.*, Aug., 1915.
[2] *Met. Chem. Eng.*, Oct. 1, 1915.

TUNGSTEN

By Colin G. Fink

The year 1915 was one of the most spectacular years in the history of the tungsten industry. In the first quarter of the year the rate of ore production was about the same as that of 1914 and 60 per cent. concentrates sold as low as $5.80 per unit. In the spring England and her allies placed in this country large war orders for munitions and this caused a great demand for tungsten for high-speed cutting tools and other special steels. Soon after the British government placed an embargo on the exportation of tungsten ore and products from Burma and every other part of the British possessions, importations from abroad dropped to practically nil. Prices began to soar; in May the value of tungsten concentrates had almost doubled and at the close of the year ore was being sold in this country at $50 and $62.50 per unit. This increase in value of 1000 per cent. greatly stimulated prospecting throughout the various States and tungsten mining was given an impetus "as great and as stirring as the great Leadville strikes of years ago or the more recent Cripple Creek boom."

As a direct consequence of this "boom" the output of tungsten ores in the United States attained in 1915 the record figure of 2165 short tons of concentrates carrying 60 per cent. of tungsten trioxide and valued at more than $2,000,000.[1] The output was more than double that of 1914 and almost five times in value. All indications are that the boom will continue through 1916.

In the table below the weights are given in short tons of concentrates of 60 per cent. WO_3, which is the commercial basis in this country.

PRODUCTION OF TUNGSTEN CONCENTRATE IN THE UNITED STATES (a)
(In tons of 2000 lb.)

Year.	Production.	Value.	Average per Ton.	Year.	Production.	Value.	Average per Ton.
1906	928	$348,867	$376	1911	1,139	$407,985	$358
1907	1,640	890,048	543	1912	1,330	502,158	377
1908	671	229,955	343	1913	1,537	672,118	438
1909	1,619	614,370	379	1914	990	435,000	439
1910	1,821	832,992	457	1915	2,165	2,000,000	924

(a) Statistics reported by F. L. Hess, U. S. Geological Survey. Figures for 1915 preliminary.

The price per pound of tungstic acid in the ore increases as the percent-

[1] Frank L. Hess, U. S. Geol. Surv.

age of tungstic acid in the ore increases. The "unit system" is explained in detail by W. M. Foote.[1] A common form of unit price is "$40 per unit (20 lb.) WO_3 per net ton of ore guaranteed to contain 50 per cent. or better WO_3 with bonus or penalty of 20 cts. per unit for each unit over or under 50 per cent."

The price of tungsten as metal or as ferrotungsten, for use in the steel industry, rose from $1 per lb. in January to $8 per lb. in December. The latter price equalled that of silver in that month. The prices in 1914 were 67 cts. up to $1.35 per lb. of tungsten. Tungsten steels in 1915 ranged from 60 cts. to $3 per lb.

The imports of ore, tungsten metal and ferrotungsten were seriously affected by the British embargo. According to the report of the Bureau of Foreign and Domestic Commerce 1595 tons of ore valued at $1,044,536 was imported in 1915 against 267 tons of ore in 1914. "Small tonnages of Japanese scheelite, Peruvian huebnerite and some Bolivian wolframite entered this country but not in lots large enough to disturb market conditions."[2] The imports of tungsten metal and ferrotungsten in 1915 amounted to 7 tons valued at $9588 as compared with 192 tons valued at $219,506 in 1914.

United States

Arizona.—The largest producing mine was the Dragoon Tungsten in Cochise County; the shipments to the reduction works at Rochester, N. Y., were at the rate of 6 tons of concentrates per day during the last 2 months of the year. The ore is mainly huebnerite, manganese tungstate. One of the most important discoveries during the year was the uncovering of a vein of wolframite for a depth of 800 ft. in the old workings of the Tiptop silver mine, the tungsten having been ignored when the property was worked for its silver ores. A mill was erected to concentrate the ore and also work the tailings and dumps of the old silver mine.[3] The Tiptop mine is the largest of the Yavapai County mines. Huebnerite and wolframite occur in all of the workings. The tungsten-bearing area extending from the Tule Creek district to Tiptop and beyond is extensive and a considerable area is still open to location. The pegmatite appears as a centralized dike with isolated outcrops that have no surface connection with the main body.[4] The Primos Chemical Co. erected a mill at Dragoon, Cochise County, and the National Tungsten Co. one at Arivaca. At Yucca, the Yucca Tungsten Mines Co. opened up their property and started a milling plant. Ore shipments

[1] Min. Eng. World, **44**, 279 (1916.)
[2] F. L. Hess, U. S. Geol. Surv.
[3] F. R. Dyas, *Min. Eng. World*, **44**, 286 (1916).
[4] W. P. de Wolf *Eng. Min. Jour.*, **101**, 680 (1916).

were also made from "Tungsten Mines" in Mohave County, Camp Wood, Oracle, and other points.

California.—Since 1914 California is the largest tungsten producer in the United States. Previous to 1914 Colorado turned out annually over 60 per cent. of the country's production and held this record for 14 years. California's output during 1915 was approximately 1050 tons of 60 per cent. concentrate. The predominating mineral is scheelite; appreciable quantities of wolframite, huebnerite and ferberite also occur in some of the districts.

San Bernardino County.—The Atolia district in the Mohave Desert is the largest scheelite producer in the world. The "tungsten boom" in the fall of the year was one of the liveliest the State has encountered for years: "Claims for miles in all directions from Atolia were vigorously prospected and large shipments of ore and concentrates were made. Several rich strikes were reported, including the discovery of a new field extending to within a few miles of Randsburg, Kern County. In the main Atolia district, discoveries of high-grade scheelite were made on the Osdick, Scheelite and other properties.[1] The population of Atolia was 50 in January and 500 in December. The Atolia Mining Co., the chief producer, erected a new concentrating plant of 100-ton capacity. To accommodate the large influx of miners and laborers the company erected a "tent city." The rate of production of the Atolia Co. increased from 8 to nearly 100 tons per day toward the close of the year. Atkins, Kroll & Co. of San Francisco are managers of the Atolia properties. About 300 men were employed in the Atolia mill by December, 1915. The company has developed new veins and pockets on the Papoose, Paradox, Pinte, Churchill, and Spanish Lease. One of the shafts of the Churchill mine was sunk to over 100 ft. The section known as the "Potato Patch" near Atolia, employs 50 men whom the Atolia pays as much as $3 per 8-hr. day. The daily production in December was 300 lb. of high-grade scheelite besides a ton of low-grade. The Potato Patch has been a wonderful producer; pieces of scheelite weighing over 100 lb. have been found.[2] The ore is found in alluvial deposits on top of bedrock. The mineral was discovered in the Atolia district in 1910.

One of the veins of the Terra Maria mine, near Atolia, is 3 ft. wide. The shaft is about 50 ft deep. The Osdick, Scheelite and Toboggan mines lie outside of the Atolia Co.'s claims. In the eastern section of San Bernardino County, 100 miles from Atolia, a number of important developments have occurred. Rich tungsten finds were made in the Kelso, Ivanpah and Cima districts. Ivanpah is less than 20 miles from

[1] A. H. Martin, *Min. Eng. World*, **44**, 295 (1916).
[2] *Min. Sci. Press*, 1916, 318.

the Nevada State line; the district contains copper besides tungsten. In the Clark Mountains wolframite was found. In the Kelso district the Globe Mining Co. started operations and shipped the ore east. Cima is a silver-bearing district. All indications are that scheelite occurs through the entire length of the county from Atolia to Ivanpah.[1] The 12 claims of the Mojave Tungsten Co. are located near the State boundary about 19 miles from Roach, Nev. The company was incorporated in November and capitalized at $1,000,000. Two of the claims were opened by shafts, one to a depth of 60 ft., the other to a depth of 165 ft. The property is well equipped with power hoists, steam drill, pumps, etc. Plans were made for a modern mill and concentrating plant. The ore of the Jack claims is a pure wolframite; that of the Arcadia claim is scheelite.[2] About 15 tons of ore were shipped in 1915.

Kern County.—This county is directly west of San Bernardino County. The tungsten district of Kern is geologically a part of the Atolia district. In the fall of the year a new mill was erected near Jawbone canyon, in the western section of the district (Kelsey Creek). The Sunshine mill near Randsburg was equipped for a capacity of 20 tons. Work was started in deepening the Sunshine shaft the belief being that ore will persist below the 500 level. Several tons of ore were taken from the Consolidated mine near Randsburg. A number of new discoveries of scheelite in quartz were reported from the western slope of the Rand Mountains. The ore from the Powell Rand Mountain claims were shipped to the mills at Atolia and Johannesburg. Some lots contained appreciable quantities of gold which was recovered. In the Stringer district about 100 men were engaged through the winter (1915–1916) working with jigs and dry washers recovering both tungsten and gold. Some of the men were said to average $25 a day. The men often had to pay lease as high as $1 per sq. ft. of ground. The scheelite here occurs both in quartz and placer form.

Nevada County.—The only producing mine in the district was the Union Hill at Grass Valley (about 40 miles north of Sacramento and about 325 miles north-northwest of Atolia). The mineral is scheelite which is found associated with quartz veins.[3] Several shipments of ore were made to the Wolfe Tongue Mining Co. at Nederland, Colo. and to Atkins, Kroll & Co. at San Francisco. The method of grading the scheelite for shipment to the buyer is by picking after drying and cobbing. The specific gravity of pure scheelite is 6 and that of quartz 2.6 whereas the "pure" mine specimens of scheelite have a density of about 5.42 or about 84 per cent. scheelite mineral. The various mine lots are looked over by the

[1] *Eng. Min. Jour.*, **101,** 411 (1916).
[2] See report of Morgan and Finlay, New York.
[3] P. B. McDonald, *Min. Sci. Press*, 1916, 40.

man sorting and judged by the eye as to how much quartz accompanies the "pure" scheelite ore. How close ore lots can be estimated in this way is shown by the following figures: Lot one, estimated by the sorter as 65 per cent. WO_3 was found by chemical analysis to contain 65.4 per cent.; a second shipment estimated as 25 per cent. WO_3 analyzed 26.2 per cent.

Colorado.—Colorado is the second largest producing State in the Union. The output of the State was almost 1000 tons of 60 per cent. concentrates (ferberite). During the first half of the year mining was dull throughout the State. In the summer there was a general revival particularly in the manganese, zinc and tungsten districts due to the rapid rise in metal prices. By the fall of the year an "old time" boom throughout the tungsten area had started and hundreds of miners and prospectors were in the field; old mines were re-opened, dumps were worked over and several new and important ore-bearing localities were discovered.

Boulder County.—The main centers of activity were the towns of Nederland, Lakewood, Stevens Camp, Bummer Gulch and at Boulder Falls. In the first few months of the year there were about 1000 men occupied in the industry; in May over 3000 had already enrolled.[1] The output of the district was equivalent to 960 tons of 60 per cent. WO_3 concentrates according to the figures of the Boulder County Metal Miners' Association. This output was valued at $1,688,000. The mill of the Primos Chemical Co. was the center of activity. The company largely increased its holdings.

One of the immediate products of the prosperity of the tungsten mining industry was the erection of a modern 40-ton concentrating mill by the Boulder Tungsten Production Co. This mill is very well described by H. C. Parmelee.[2] Within 4 weeks of the day the mill was started, and working only two shifts per day, its entire cost was recovered in the value of products sold—and this record was accomplished with mill feed averaging about 1 per cent. WO_3 and sometimes less. Electric power is used throughout the plant. The main features of the ore-milling process are, roll crushing, screening, jigging, hydraulic classification, ball milling and table concentration. There are no stationary canvas tables. Excepting the ball mill, which receives only the sand tailings from the concentrating tables, all grinding is done with rolls and after each reduction in size the pulp is dressed for the recovery of free mineral. All middlings are kept in closed circuit, and the only tailings rejected are those from the slime tables. At the present time the recovery is averaging 87 per cent. The importance of jigging is indicated by the fact that the

[1] *Min. Eng. World*, **44**, 311 (1916).
[2] *Met. Chem. Eng.*, **14**, 301–4 (1916).

first two products, from jig and coarse table, represent 85 per cent. of the total recovery.[1]

The tungsten belt of Boulder County extends at least 13 miles northeasterly from Nederland.[2] Good showings were made as far as and beyond Sunshine. The Grand View gold mine was unwatered and reopened. Toward the close of the year a shoot of tungsten ore (ferberite) 18 in. wide was opened up on the 16-ft. level for a distance of over 30 ft. Years ago when Grand View was a gold producer, the ferberite was looked upon as "black iron" and was thrown aside as a useless gangue. The presence of the heavy tungsten mineral was responsible for the early day inefficient concentration of the gold and silver.

A typical analysis of Boulder high-grade concentrate is given by H. Fleck as follows:[3] WO_3 59.99 per cent.; FeO 32.57 per cent.; MnO 1.02 per cent.; SiO_2 8.32 per cent.; P trace; S none. The mineral proper constitutes nearly 90 per cent. of the concentrate. At a few of the mills the iron is partly removed by Whetherill magnetic separators. The Tungsten Products Co. was incorporated at the close of the year for the purpose of manufacturing tungstic acid (WO_3).[4] The raw material is cheap low-grade ore mined near Nederland. The ore is mixed with soda ash and roasted on a reverberatory hearth. The roasted mixture is then transferred to vats filled with boiling water. The sodium tungstate goes into solution. The solution after passing through a vacuum filter is treated with muriatic acid whereby the yellow tungstic acid, WO_3, is thrown down. The precipitate is separated from the liquor by decantation and filtration and forms a product of immediate commercial value.

Toward the close of the year the Nederland Tungsten Mines & Development Co. was incorporated for $1,000,000, with headquarters at Nederland. The company controls a 100-acre tract of mining property on the divide between Boulder and Beaver Creeks. Active operations were commenced early in 1916. Other new mining companies are the Boulder Tungsten Production Co. and the Nederland Tungsten Co., both of which were active producers in 1915.[5]

Gilpin County.—The Gilpin tungsten district is one of the past year's important developments.[6] Some 30 years ago the Old Iron Hill mine at Hughesville, 3 miles north of Black Hawk, was a producer of silver. At that time the miners frequently encountered what they considered worthless iron ore. Samples of the dumps were sent to Denver last

[1] Other concentrating methods are described by H. Fleck, *Col. Sch. Mines Quart.*, Oct., 1915. Also Mineral Industry, **22**, Tungsten.
[2] *Min. Amer.*, Nov. 13, 1915.
[3] *Min. Sci. Press*, 1916, 166.
[4] *Met. Chem. Eng.*, **14**, 132 (1916).
[5] For a description of the Wolf Tongue Mill see Mineral Industry, **22**, 763. The Vasco Mining Co. of Boulder bought tungsten ores of all grades.
[6] *Min. Amer.*, Dec. 25, 1915. Discovery made by P. S. Roy.

November and assayed 0.90 to 28.20 per cent. WO_3 besides silver, lead, zinc and gold. The property, over 100 acres, was acquired by a Denver concern and operations were soon after started. This concern, called the Gilpin Tungsten Production Co., has cleaned out the old Iron Hill tunnels and has since opened a rich vein of ferberite. A mill was started building and is about completed. Among the machinery installed is a Denver quartz mill of 30-ton capacity.

San Juan County.—This new tungsten district in Colorado promises to rival the Boulder district. The Dawn of Day and other producing mines are in the vicinity of Silverton. Geologically this area differs in many respects from the Boulder area, although both possess typical ore-bearing veins. The San Juan ore is huebnerite in quartz and the minerals separate freely.[1] The first important shipment from the district was made in November when 2.5 tons of 72 per cent. concentrate was forwarded from the Dawn of Day mine to Pennsylvania. The ratio of concentration was 10 to 1.

Other Localities.—Discoveries of tungsten were reported on the Crist property near Georgetown, Clear Creek County. At the Graphic Mine, Magnolia, ore of commercial value was found. In the New York Gold Mines near Sunshine tungsten deposits were opened and systematic development was begun. A rich find was reported on a claim about 10 miles southeast of Victor, near Colorado Springs. Gold, silver and copper are also in the ore. The claim is controlled by the Wolframite Gold Mining Co. of Wheeling, W. Va.

Idaho.[2]—The total output of Idaho in 1915 amounted to about 30 tons of 50 per cent. concentrate, equivalent to 25 tons of standard 60 per cent. concentrate. Tungsten ores occur in widely scattered districts over the entire state. In the fall of the year vigorous prospecting took place and the chances of producing an appreciable tonnage in 1916 are very good. The principal shipments in 1915 were from Blaine, Lemhi and Shoshone Counties.

Blaine County.—New discovery of tungsten deposit was made on Soldier Mountain. About 5 tons of high-grade ore was shipped to Salt Lake City. The deposit (wolframite) occurs in a fissured zone near the center of a dike of porphyry that has been classified as a variety of trachyte. The stringers of quartz wolframite are from ¼ to 2 in. wide. The Nelson tungsten prospect, Blaine County, is a contact vein of porphyry-breccia cemented with narrow bands of quartz in a contact between yellow porphyry and ancient limestone-quartzite sediments. Wolframite speci-

[1] *Eng. Min. Jour.*, **101**, 23 (1916).
[2] The Idaho statistics and data are taken from a report by Robert N. Bell, state mine inspector for Idaho. See *Min. Amer.*, Mar. 11, 1916.

mens up to a pound in weight have been found. Further development is necessary. Mining conditions are favorable.

Lemhi County.—The Ima mines were worked by the Idaho Tungsten Co. They are situated at Patterson Creek. The property carries a very large deposit of ore, wolframite and huebnerite, and although of low grade, is of ideal concentrating character.[1] The deposits occur in white quartz fissure veins in a formation of precambrian sediments. Huebnerite predominates. The quartz gangue also carries zinc, lead and iron sulphides.

Shoshone County.—The old gold mine "Golden Chest" near Murray was opened up in December and several car loads of scheelite ore were shipped east. The vein of white gold-bearing quartz carries sheelite and is from 1 to 10 ft. in width. A jig was installed to treat material too fine for hand-sorting. In other sections of the Murray district scheelite occurs in lead-bearing veins.

Nevada.—According to F. L. Hess of the Geological Survey the most extensive tungsten ore discoveries in the United States during 1915 were made in White Pine County, Nevada. Next to the copper operations, the tungsten were the most extensive throughout the State.

White Pine County.—The greatest activity was in the Snake Range in the eastern part of the county. Veins of scheelite were found at several places between the Minerva district, 30 miles south of Osceola, and Cherry creek, 50 miles north of Ely. Some of the veins were formerly prospected for precious metals, but the scheelite was not recognized.[2] Near Cherry Creek the American Smelting and Refining Co. has taken over a large scheelite prospect. Active operations were begun early in 1916. Tungsten was also found across Steptoe valley on the east side of Shell Creek Range. Twenty-five miles southeast of Cherry Creek a huebnerite prospect was developed at Tungstonia. Here a mill was erected late in the year and shipments of concentrates 60 per cent. and better were begun early in 1916. Tungstonia is probably the largest huebnerite producer in the United States. The main vein is 12 to 20 in. wide traceable on the surface for 3000 ft. There are several other veins 2 to 5 ft. wide.[3] South of Tungstonia, at Sacramento Pass the Doyle Mining Co., a San Francisco concern, operated a scheelite property and erected a small mill.

One of the chief producers in the county was the United States Tungsten Corporation whose property is located about 12 miles south of Osceola. The nearest railroad shipping point is Ely, 42 miles northwest. During 1915 40 tons of concentrates was produced and the same

[1] See *Min. Eng. World*, **44**, 309 (H. W. Ingalls).
[2] F. L. Hess, *Bull. U. S. Geol. Surv.*, Jan. 17, 1916.
[3] *Min. Sci. Press.* 1916, 485.

amount in the first 3 months of 1916.[1] The property consists of 64 claims comprising about 1200 acres on the western side of Snake Range. The ore consists principally of huebnerite and averages about 2 per cent. tungstic acid. There are seven well-defined veins and in addition there is a large placer deposit which is being treated on the ground-sluicing method. The property was closed down until August. With the rise in price per unit, operations were resumed and the concentrating mill remodelled. This has a capacity of 75 to 80 tons of ore per day. The mill is run by water power for 8 months of the year and the remainder of the year by semi-Diesel type engines. The cheap water power materially cuts the cost of operating the plant. The ore is put through crusher, rolls, and a ball mill and then run over vanners. The tailings assay not over 50 cts. per ton in tungsten which reflects favorably on the efficiency of the mill. The corporation is capitalized for $1,000,000.

Both north and south of the U. S. Tungsten Corporation's property a number of new localities were opened up. A new camp, Scheelite, was started on Willard Creek and a mill was to be erected. South of the U. S. Tungsten mine in the old Minerva district scheelite was taken out of the dump of the silver mine which had been abandoned 30 years ago. A 5- to 6-ft. vein was opened up at several places in the old mine containing 1 per cent. scheelite with bunches of high-grade ore.[2] The mine is owned by a Boston concern. On the east side of the Snake Range, 8 miles west of Garrison, is the Bonita scheelite property of J. D. Tilford. A small mill was erected which began operations late in the fall. South of the Bonita camp at the head of Big Wash, under Mt. Washington a very high-grade scheelite prospect was discovered at an elevation of 9500 ft. Several shipments of 70 per cent. WO_3 crude ore were made. Deep snow interfered with the operations. The Consolidated Tungsten Mines Co. ($500,000) controls 30 claims on Williams Creek, 45 miles southeast of Ely. The veins so far opened range from 1.4 to 13.39 per cent. tungsten. Mining is done by adits.

Humbolt County.—A 50-ton tungsten mill was erected at Toy, 18 miles southwest of Lovelocks, by Atkins Kroll & Co. of San Francisco. Operations began late in the fall. The mill is on the edge of Humbolt Lake 2½ miles from the mine, the tungsten deposits are declared to be extensive.[3]

Several veins of huebnerite were found on Mt. Patterson, Lincoln County.

Important discoveries of ore were made near the old camp of Douglas, Mineral County and operations began late in the fall. At Round

[1] Communicated by John Borg, New York.
[2] *Min. Sci. Press.* **112,** 485 (1916).
[3] W. D. Van Blarcom, *Min. Eng. World,* **44,** 317 (1916).

Mountain, Nye County, and at Spanish Springs huebnerite was dry washed from desert sands.

New Mexico.—Huebnerite concentrates were produced in considerable quantity from the dumps of the White Oaks gold mines in Lincoln County. The various properties were consolidated into the White Oaks Mines Consolidated. The company controls about 300 acres of tungsten, gold and coal lands in New Mexico. About 100 tons of tungsten concentrates were produced in 1915 of a gross value of about $30,000. The Crucible Steel Co. contracted for $500,000 worth. "The mining conditions at White Oaks are exceedingly simple; there is no water in the mines which are probably the deepest dry mines in the world. There are two stamp mills and a concentrating plant of 100 tons per day capacity. There is plenty of water for operation and plenty of fuel, a coal mine being situated on the property."[1] The mines are 12 miles from Carrizoza on the Rock Island R. R.

Some wolframite was also found near Penasco about 100 miles southeast of White Oaks, and some scheelite on Hermit Mountain near Las Vegas.

Washington.—Prospecting and developing occurred at various points in the Cascade Mountains, Cedar Canyon, Cathedral Mountain, etc., the Stevens County developments being the most important. The State's total production was about 5 tons.

South Dakota.—Next to gold, tungsten was the most important mineral product in the State during 1915. The wolframite profits of the Wasp Co. about equalled those of their gold cyanide plant.

Black Hills District.—The two large producing mines are the Wasp No. 2 at Flatiron and the Homestake at Lead. Besides the Lead-Flatiron area there are two other important areas, the Tinton and the Harney Peak. In the Lead-Flatiron district the mineral (wolframite) occurs as a replacement of dolomite[2] at and near the top of the Cambrian quartzite; the ore varies in grade from 5 to 62 per cent. tungstic acid (WO_3). In the Harney Peak pegmatite district the wolframite and ferberite occur in quartz veins and pegmatite dikes. The veins are from a few inches to a foot or more in thickness, occasionally with a pegmatite or granite wall, but usually enclosed in schist walls. In the neighborhood of Hill City, Oreville, Keystone and Spokane a large number of small veins have been identified. The ore is readily crushed and easily concentrated. The quartz veins, as a rule, produce clean ferberite with occasional scheelite but contain no pyrite, tantalite, columbite or other heavy interfering mineral. At Flatiron the ore is fine grained, extremely hard

[1] Richard Wightman, Pres. White Oaks Mines Consolidated.
[2] Jesse Simmons, *Min. Eng. World*, **43**, 816 (1915).

and tough necessitating grinding to not coarser than 30-mesh in order to make a good recovery by concentration. The ores are mostly wolframite; scheelite is a rarity and occurs only in small grains. In the Tinton district the placer deposits are probably erosion products of large pegmatite dikes containing small quantities of the tungsten minerals.

The Wasp No. 2, at Flatiron, 2 miles south of Lead, has made by far the largest production of ore in the district. In October $50,000 in dividends was distributed derived mostly from wolframite profits. (The Wasp is an old gold mine.) During 1915 the Wasp mined several thousand tons of low-grade ore later concentrated in the new mill which was started building in December. Before completion of the mill several hundred tons of ore were sorted, cobbed and crushed to about half-inch. For the first shipment (July) $8 per unit was obtained for material carrying 48 per cent. WO_3; for the last shipment in December, $51 per unit for 47 per cent. WO_3 product.[1] The total wolframite shipments in 1915 amounted to $147,000 and the total dividend distribution, $82,500. The mill was completed early in 1916 at a cost $5000. It includes a Davis roll, a 5 by 4-ft. ball mill, Richards jig, horizontal jig, classifier, elevator and Wifley tables. The capacity of the plant is about 25 tons daily.[2] The slime as it leaves the classifier passes to canvas tables 4 by 60 ft., thence to a launder and finally to a 420-ton storage tank. From here it is taken to the cyanide plant for gold recovery which at times runs very high. The mill turns out three grades of concentrates, namely, 65 per cent., 45 per cent., and 35 per cent. WO_3; the last one is from the canvas tables.

The Homestake is likewise a gold-tungsten mine, whose total dividends amounted to $2,210,208 during 1915. Wolframite was produced from the claims west of the great open cut, in the Hidden Fortune ground. All of the ore taken out was hand-sorted and shipped. At the Golden Reward near Spokane wolframite deposits were being developed. The Black Hill Tungsten plant was being repaired at the close of the year.

Tungsten in Foreign Countries

North America

Canada.—The most important tungsten locality is Halifax County, Nova Scotia.[3] The mineral is chiefly scheelite. Other localities are Salmo and Willow Creek, British Columbia and Risborough and Marlow,

[1] Edward Manion, Superintendent, Wasp No. 2.
[2] *Min. Sci. Press*, 1916, 140.
[3] See Mineral Industry, **23**, 749.

Beauce County, Quebec. The Nova Scotia scheelite is first concentrated by the wet process. It is then roasted to render it magnetic and put through a magnetic separator. The total production of Canada in 1915, is estimated at 15 tons. The prospects for 1916 are exceptionally good now that the government has started a systematic survey and is encouraging development of mines and prospects.

Mexico.—Mexico entered the field as soon as the demand for tungsten reached its high mark in the fall. Small shipments were made from various localities. At the Washington mines near Huepec in Sonora scheelite was found associated with copper.

South America

Argentina.—Deposits of wolframite are found in several places in the Province of San Luis. In the Condores district of the province the mineral occurs in quartz veins that are nearly vertical. These have been explored to a depth of 600 ft. The mill is equipped with jigs and tables. Mines in the Carolina district were operated for part of the season. The transportation facilities are poor and wood is the only available fuel. The production in 1914 was 394 metric tons.[1] The production in 1915 was somewhat higher, on the basis of preliminary reports. The exports in 1915 were 158 tons.

Bolivia.—Wolframite, scheelite and huebnerite are all found along the eastern cordillera in Bolivia. The principal mines are at Quimza Cruz, in the province of Ayopaya, N. W. of Cochabamba (Kami and Chicote) and near Uyuni, at Salasala.[2] Some of the ore localities are 13,500 to 16,500 ft. above sea level.[3] The production in 1914 was 290 tons of 60 per cent. ore according to F. L. Hess. In the first 5 months of 1915, 250 tons were produced. The production for the year is estimated at 525 tons. The exports amounted to 499 tons. In most instances the increased production has been derived from low-grade deposits that were known to exist but could not be worked at a profit at normal prices.[4] The methods of mining and concentrating are usually most primitive. F. A. Savage describes the Llallagua mine as follows:[5] "The mine is located 3 or 4 miles from Catavi and 1500 ft. higher. All the formation of the region is decidedly volcanic and hot springs are frequently encountered. The tunnel penetrates the hill about 2600 ft. The ore is brought out to a coffing dump and there is parted entirely by female labor, and sacked for shipment. These women are experts in classi-

[1] F. D. Adams, Pan American Union.
[2] P. F. Bliek and M. G. F. Soehnlein, *Eng. Min. Jour.*, 101, 176.
[3] See Mineral Industry, 23, 750.
[4] Bliek and Soehnlein, *loc. cit.*
[5] *Compressed Air Mag.*, 21, 7877.

fying and seldom if ever does the ore which they have sorted fall below 60 per cent." A goodly proportion of the ore was exported to the United States.

Brazil.—American engineers located extensive deposits in the State of Espirito Santo. The deposits in the State of Minas Geraes were found to be second rate; scheelite occurs in old gold washings at Sumidouro de Marianna in this State.

Chili.—Tungsten deposits have been uncovered in the province of Taena according to a report from Sr. Jorge Romussi of Iquique.

Peru.—The greatest activity was in the Conchucos district of the Department of Anchas and Libertad. About one-half of the total mineral production of Peru is due to American capital. The cost of producing a ton of concentrates is about $500. The ores average 1.5 per cent. WO_3.[1] The production for 1915 is estimated at 250 tons 60 per cent. WO_3.

Europe

Austria and Germany.—Practically all of the tungsten ore produced in these two countries is from the Zinnwald district in the Erzgebirge, a chain of mountains between Saxony and Bohemia. The mineral is mostly wolframite associated with tin stone. Scheelite is also found here, usually as small crystals on quartz. Wolframite also occurs in the Harz Mountains.[2] Before the European war Germany has always been a dominant factor in the tungsten market of Europe. Most of the metal and ferro-alloy were made in Germany and exported to her neighbors, France taking the larger percentage. Germany's consumption is from 30 to 40 per cent. of the world's production. The production of the two States in 1915 is estimated at 250 tons of 60 per cent.

Great Britain.—The production of the British Isles in 1914 was 205 tons valued at £19,722 as compared with 182 tons valued at £17,483 in 1913. Though Great Britain controls about half of the world's supply of tungsten ores British high-speed steel makers obtained their tungsten almost entirely from Germany before the war. To relieve the situation after war broke out, the government erected a plant at Widnes and one at Sheffield for the extraction of the metal from the ore. To insure an adequate supply of ore the embargo was placed and no tungsten ore can now be exported from any of the British possessions.[3] According to the Geological Survey of the United Kingdom[4] Cornwall produces nearly all of the tungsten ores obtained in the British Isles. A few tons are also produced in Devon and Cumberland. The mineral is mostly

[1] *Min. Jour.* (1915), p. 668, See also MINERAL INDUSTRY, **23**, 751.
[2] For further details see MINERAL INDUSTRY, **23**, 752.
[3] See under Burma below.
[4] *Min. Mag.* (1916), pp. 172–3.

wolframite. Some scheelite is also found, chiefly in Cumberland. In Cornwall the most important district is between Camborne and Redruth, where the East Pool, South Crofty, and Tincroft mines are regular producers. The ore is here found in veins in the granite and metamorphosed slate. The Cumberland deposits are north of Skiddaw near Caldbeck; wolframite and scheelite occur in veins in mica schist and are associated with galena, blende, pyrite, molybdenite and bismuth. The presence of tin in the Cornish ores is objected to by some of the steel concerns, tin being considered as fatal as carbon. Accordingly, the ground ore is passed two or three times over a Whetherill magnetic separator. Before the war the Germans used the Ullrich (Krupp) separator on the Cornish ores. Mr. T. R. Phillios is the "tungsten" minister of England whose duty it is to see that his country is well supplied with ore, ferrotungsten and metal. During the course of the year England imported large quantities of ore from Burma, Australia, Rangoon and Japan. In the month of December the imports amounted to 200 tons of 60 per cent. ore.

Portugal.—The production of tungsten ores in Portugal passes almost entirely into English hands. The Wolfram Mining & Smelting Co., Ltd., paid a dividend of 15 per cent. as compared with 7.5 per cent. in former years. The company has entered into a long-term contract with the factories at Widnes and Sheffield, England. Prices of ore in Portugal advanced from $6.18 to $18.25 per unit during the course of the year.[1] In 1914 the production was 880 metric tons of 65 per cent. concentrates or 967 tons of 60 per cent. Among the largest producers are the Borralha mine at Montalegre near Via Rial; the Panasqueira mine at Covilha near Castelo Branco; and the Teixugueiras mine at Parada near Braganca in the far north. The combined output of these three mines in 1915 is estimated at 1000 metric tons. The Portuguese government removed the embargo on tungsten, since it is not employed in any of the home industries. The arrangement during the second half of the year was that the United States, France and England receive 30 per cent. of the output. In the province Beira tungsten deposits in quartz were discovered.[2] Gaston, Williams & Wigmore, New York, imported several hundred tons from Portugal in the latter part of 1915.

Asia

Burma and the Malay States.—Burma continues to be the largest tungsten ore producer of the world. Lode mining in Tavoy is recorded by Helfer in 1839 and there is ample evidence of extensive mining opera-

[1] Consul General W. L. Lowrie, Lisbon, *Comm. Rept.*, Aug. 17, 1915.
[2] Compare Mineral Industry, **23**, 753.

tions having been carried out in the 16th or 17th century by the Siamese and Chinese[1]

The year 1915 marks the passing of the Burma tungsten industry out of German into British hands. In spite of the urgent need of tungsten by the British home government for the manufacture of tool and special steels for the munition factories, Burma failed to respond promptly. Lack of good means of transportation and lack of sufficient guarantee of title were but two of the many handicaps confronting the mine owners. Accordingly, in the fall of the year the British government took an active hand in the mining and marketing of the Burmese wolfram, started to build new roads and bridges, imported labor, and appointed new heads and superintendents of mines and claims that were lying practically idle.

In November the government published at Delhi the "Wolfram Rules of 1915." Two of the more important clauses are as follows: "Any person holding a license to prospect tungsten shall obey any direction which he may receive from the collector (appointed by the home government) as to the manner in and scale on which he shall carry on his mining operations under the license." Any person found to be "detrimental to the development of the tungsten industry may be removed from the district by order of the collector." Most of the mine owners objected to the importation of the 1500 Chinese coolies who knew little about mining operations and had been promised comparatively high wages. Another serious objection was the maximum price of 55s. per unit fixed by the government at a time when prices in neutral markets were several times this.

The intervention of the government stimulated the production, which totalled 2116 long tons of wolframite concentrates for the year 1915, averaging about 67.5 per cent. WO_3 as compared with 1631 tons in 1914.[2] The ore (wolframite) occurs primarily in veins composed chiefly of quartz but carrying also columbite, tourmaline, molybdenite and very occasionally, cassiterite.[3] These veins traverse granite and a series of metamorphosed sediments composed of slate, schist and quartzite and known as the Mergui series. According to J. Page of the Geological Survey of India there are in addition to the Mergui series two considerable series, an archaean permio-carboniferous and a tertiary-to-recent. The wolfram-tin-bearing belt of granite and metamorphoid rock runs on northward from Mergui and Tavoy into the Southern Shan States and is being exploited in the Bawlake State.

Although the development of the tungsten industry in Burma has

[1] *Min. Jour.*, **111**, 197 (1916).
[2] *Min. Jour.*, **111**, 123 (1916).
[3] *Min. Eng. World*, 1916, 478.

been most rapid, the production 5 years ago being practically nil, the methods are still comparatively primitive.[1] The greater part of the ore is derived from the quartz-wolframite lodes which are worked by quarries and open-cut workings. Among the companies engaged in wolfram mining are the Wolfram Mining and Smelting Co., The Rangoon Mining Co., The Hindoo Chaung Dredging Co., the Egane Mining Co., the Burma Malaya Mines, Finlay Fleming and Co., and Gillanders Arbuthnot. The prospects for 1916 are most promising.

Federated Malay States.—According to J. B. Scrivenor, Geologist, Batu Gajah, the production of tungsten ore concentrates in 1915 amounted to 4901 pikuls averaging about 67.5 per cent. WO_3. Taking the pikul at 133.3 lb. we find the output equivalent to 334 metric tons of 60 per cent. concentrate. About 80 per cent. of the product was wolframite, the balance scheelite. The chief producer was the Titi Mines Co. whose output totalled 1199 pikuls. The important tungsten States are Selangor, Negri, Sembilan and Perak.

Japan.—Owing to the large demand for tungsten, particularly in the fall of the year, the mining of tungsten ore was stimulated and several companies tried to meet the export demands. The total output amounted to 250 metric tons The mines of the Mitsui Mining Co. in Chosen are not far distant from iron and coal mines and conditions seem favorable for converting the concentrates into ferrotungsten before shipment.[2] In the review of the mineral industry of Japan by H. W. Paul of Yokahama the production of tungsten ore in 1914 is figured at 195 metric tons valued at 187,712 yen ($94,000).[3] At the Suan Concession in Chosen scheelite occurs associated with gold. Japan received from China about 75 tons of ore (wolframite).

Australia and New Zealand.—In the fall of the year the Imperial Government entered into an agreement with the Commonwealth Government of Australia whereby all scheelite and wolframite produced in Australia is to be turned over to the Imperial Government. The price was fixed at 55s. per 20-lb. unit as in Burma and other colonies. The grade was fixed at 65 per cent. minimum WO_3; impurities not to exceed 0.5 per cent. tin and 0.5 per cent. bismuth.[4] The production of Queensland in 1915 is estimated at 525 tons, the greater part of which came from the Bamford district. New South Wales produced both scheelite and wolframite estimated at over 300 metric tons. The scheelite is found in patches and pockets near Hillgrove. New discoveries of ore were reported from several localities in the eastern section of

[1] *Min. Jour.*, **111**, 123 (1916).
[2] Communicated by E. Tatsumi, Mitsui Mining Co.
[3] *Eng. Min. Jour.*, **101**, 134 (1916).
[4] *Queensland Gov. Min. Jour.*, Oct. 15, 1915.

Australia. Wolframite was found in the Sugarloaf district occurring in a quartz reef; the new claim is controlled by the Allison Wolfram Syndicate. A shaft was sunk and a mill was started. The King Island Scheelite Co. was incorporated at Melbourne for £50,000 for the development of the King Island deposits. The ore assays 2.34 per cent. WO_3.[1] New Zealand's production in 1914 amounted to 250 tons 60 per cent. concentrate.[2] Scheelite was found at a number of the New Zealand gold mines.

Africa

British South Africa.—Wolframite is found with the tin ore at Kuils River in the vicinity of the Cape Peninsula. Scheelite is more widely distributed: it is found in the southern tin belt, in the Rooiberg area and in the Oshoek and Swaziland tin fields.[3] The British government is promoting the industry. At Nakais, South-West Africa, a new wolfram mine was opened up. No shipments were made in 1915.

The World's Output of Tungsten Ores

The following table shows the production of tungsten ores in all of the important tungsten states of the world. Compared with 1914 the total world's tonnage in 1915 showed an increase of about 50 per cent. due to the exceptionally favorable conditions in the steel industry.

PRODUCTION OF TUNGSTEN ORES
(Metric tons; 60 per cent. WO_3)

Country.	1911.	1912.	1913.	1914.	1915.
North America:					
United States	1035	1210	1397	900	1970
South America:					
Argentine	621	638	539	394	(a)
Bolivia	336	497	564	832	600*
Peru	52	214	300	130	250*
Europe:					
England	264	193	182	205	250*
France	171	230	245*	(a)	(a)
Germany-Austria	126	167	150*	220*	250*
Portugal	980	1330	800	967	1400*
Spain	96	169	150	84	(a)
Asia:					
Burma	1020	1905	1732	1868	2265
Siam	182	108	281	30	(a)
Japan	261	205	297	195	250
Australasia:					
Queensland	682	860	543	435	525*
New South Wales	465	271	209	(a)	300*
Total world production	6999	8780	9775	8000*	12,000*

Statistic reported by F. L. Hess of the U. S. Geological Survey and foreign consuls.
(*a*) Statistics not available.
* Estimated.

[1] *Min. Jour.*, 1916, 143.
[2] F. L. Hess, *Min. Res. of U. S.*, 1914, 939, U. S. Geol. Surv.
[3] *So. Afr. Min. Jour.*, 1915, 344.

Technology

Ferrotungsten and Tungsten Metal.—Fred. M. Becket patented a process for the removal of phosphorus from scheelite before reducing same to metal or ferrotungsten.[1] The ore is treated at red heat with sulphuric acid whereby the phosphorus goes into solution and the tungsten remains insoluble. The tungsten factory at Luton, England, fuses the finely ground wolframite with soda whereby sodium tungstate is formed. This tungstate is broken up by hydrochloric acid resulting in the formation of yellow tungstic acid. The oxide after filtering and drying is mixed with charcoal, packed into large crucibles and heated for 18 hr. in a reverberatory furnace. The slag-like mass of metal produced is crushed and ground to a fine powder (98 per cent. pure). In the manufacture of ferrotungsten at Luton, large 3-ton electric furnaces are used. The product contains from 50 to 80 per cent. tungsten.[2] Over 90 per cent. of all the tungsten produced in the world is made up into ferro-alloy and tungsten steels. Before the war the bulk of the ferrotungsten was made in Germany. The Vanadium Alloys Steel Co. of Pittsburgh has since started manufacturing on a large scale, ferrotungsten ranging from 70 to 80 per cent. W. In January, 1915, the price for tungsten as metal or ferro-alloy was $1 per lb., in June $2, and in December $8. Prices in London were much lower. The Crucible Steel Co. is the largest consumer of ferrotungsten in this country.

Magnet Steel.—The demand for tungsten magnet steel has been unusually large due to the heavy consumption by automobile manufacturers. The steel contains about 6 per cent. W and 0.6 per cent. C.[3]

High-speed Steel.—American high-speed steel contains about 18 per cent. tungsten beside about 4.5 per cent. chromium and 0.6 per cent. vanadium. Some of the newer steels contain in addition 3 to 5 per cent. cobalt, which apparently increases the red-hardness.[4] Although American and other manufacturers have adopted the electric furnace for the manufacture, Sheffield still prefers the crucible process claiming that better results are obtained in melting smaller quantities. The year 1915 has been the "biggest" in the history of the steel. Prices for high-speed steel ranged from 60 to 75 cts. per lb. in January to $3 per lb. in December, 1915, as compared with $19.25 and $30.25 per gross ton for Bessemer. This exceptional rise has been largely due to the "war orders" received from Europe.

Other Tungsten Alloys.—Tungsten alloys readily with nickel, cobalt,

[1] U. S. Patent 1153594, Sept. 14, 1915; *Met. Chem. Eng.*, **13**, 923.
[2] Compare *Min. Jour.*, 1915, 467 and H. Fleck, *Col. School Mines Quart.*, Oct., 1915.
[3] For full details see Manufacture and Uses of Alloy Steels by Henry D. Hibbard, *Bull.* **100**, U. S. Bureau of Mines.
[4] See H. D. Hibbard, *loc. cit.* Also J. O. Arnold, *Iron Age*, **97**, 1207.

molybdenum, chromium, iron, manganese, vanadium, uranium, and titanium. The nickel-tungsten alloys were investigated by R. Irmann,[1] and H. Kreusler.[2] Irmann found that the 18 per cent. W alloy was ductile and very resistant toward dilute sulphuric acid. F. A. Fahrenwald proposed the use of tungsten-molybdenum alloys in place of platinum in dental work.[3] Hans Kaiser produced a tough ductile alloy by the addition of 1 per cent. thorium and 0.2 per cent. platinum to tungsten.[4]

Properties of Tungsten.—The field test for tungsten is described in detail by F. L. Hess.[5] The finely ground sample of ore is boiled in hydrochloric acid; if tungsten is present the yellow oxide, WO_3, separates out. On the addition of a small piece of zinc the oxide turns blue.[6]

A. G. Worthing records the melting point of tungsten as 3357° C., which is about 100° higher than the value given by Langmuir.[7] O. W. Richardson calculates that tungsten has 6.16×10^{22} atoms per c.c.[8] The spectrum of tungsten was investigated by Barnes, Compton, Gorton[9] and others. The properties of tungsten are described by C. G. Fink in *Trans. Amer. Electrochem. Soc.*, **22,** p. 503 and MINERAL INDUSTRY, **23,** 759.

New Applications of Tungsten.—Tungsten is one of the few metals that serves as a very reliable make-and-break contact with mercury (in physical apparatus) since it neither amalgamates nor corrodes. B. Thieme[10] constructed an adjustable multiple spark gap for wireless telegraphy.

In the fall of the year the Victor Talking Machine Co. put the tungsten needle or stylus on the market.[11] On account of the high price for platinum (up to $100 per oz.) the use of tungsten in place of platinum points in dental work increased rapidly during the course of the year. The tungsten lamp business was exceptionally prosperous; in this country over 150 million lamps were manufactured.[12] A noteworthy development was the tungsten enclosed arc lamp which was put upon the market in the fall of the year.[13] The intrinsic brilliancy is about 10,000 cp. per sq. in. The tungsten X-ray tube has found world-wide recog-

[1] *Metall u. Erz*, **12,** 358 (1915).
[2] U. S. Patent 1110303 (1915).
[3] *Bull. Amer. Inst. Min. Eng.*, 103, 1916.
[4] U. S. Patent 1167827 (1916).
[5] *Loc. cit.*
[6] See also *Col. School Mines Mag.*, Dec., 1915; *Min. Amer.* (1916), 16. M. L. Hartmann, *Chem. Abst.*, **10,** 1146 (1916).
[7] *Jour. Franklin Inst.*, **181,** 417 (1916). *Phys. Rev.*, **7,** 497 (1916). Langmuir, *Phys. Rev.*, **6,** 157 (1915).
[8] *Phil. Mag.*, **30,** 295–9 (1915).
[9] James Barnes, *Phil. Mag.* **30,** 368 (1915). A. H. Compton, *Phys. Rev.*, **7,** 498 (1916). W. S. Gorton, *Phys. Rev.*, **7,** 203 (1916).
[10] *Deutsch. physikal. Gesells. Verhandl.*, **17,** (13) pp. 250–2 (1915). See also J. von Kowalski, *Chem. Abstr.*, **9,** 2741 (1915) and Hans Boas, U. S. Patent 1152272 (1915).
[11] See MINERAL INDUSTRY, **22,** 770 (1913).
[12] An interesting application of the tungsten lamp to the mining industry: Under the white light of the gas-filled tungsten lamp "black jack" zinc ore is readily distinguishable from lead. Many of the zinc refineries accordingly installed these lamps. (*Elec. World* (1916), p. 104.)
[13] *Electrician* (London), **76,** 390 (1915); *Elec. World*, **67,** 52 (1916).

nition. The total consumption of tungsten for purposes other than steel approximated 5 tons or about 10 tons of 60 per cent. concentrates; that is, about one-half of 1 per cent. of the country's total consumption.

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URANIUM AND VANADIUM

By Robert M. Keeney

Uranium

At the end of the year there was probably more uranium being used than at any time in the past. This consumption, which was in the form of ferro-uranium, was due to indications that uranium causes beneficial results in steel, especially in high-speed steel. A small amount of uranium was also used as aluminium-uranium as a de-oxidizing agent in bell metal and brass.

Sources.—Carnotite ores from Colorado continued to be the principle source of uranium compounds. Except for the uranium made into alloys, very little of the sodium uranate extracted found any use, but was stored as in the past.

The producers of uranium were radium manufacturers. According to the U. S. Geological Survey reports, the output of uranium oxide mined in 1915 was 23.4 tons of U_3O_8. The National Radium Institute treated about 1000 tons of ore and from concentration of low-grade material obtained 70 tons of concentrate containing 3 per cent. U_3O_8. The Schlesinger Radium Co. treated ores containing 5000 lb. of U_3O_8. The Standard Chemical Co. did not operate its mill at Canonsburg except in parts, but developed several alloys of uranium, and worked on the use of uranium in steel.

Uses.—Alloys of about the following analysis were put on the market:

Ferro-uranium	Per Cent.
U	50.0
C	3.0
Si	1.0
V	2.0
S	None
P	0.02

Aluminium-uranium	Per Cent.
U	50.0
Al	48.0
Fe	0.5
V	1.0

The ferro-uranium was used in steel and the aluminium-uranium in non-ferrous alloys. Although the applications of these alloys have not been completely solved, the results are encouraging and indicate that:

1. In high-speed steel a small percentage of uranium may be substituted for a very large percentage of tungsten without injuring the cutting qualities of the steel.

2. The addition of a small percentage of uranium to carbon steel and cast iron improves the physical qualities to a marked degree.

3. Uranium acts as a powerful de-oxidizing agent on non-ferrous alloys.

A high-speed steel showing excellent cutting qualities contained: C, 0.78 per cent.; Mn, none; Si, 0.16; P, 0.02; W, 8.15; Cr, 3.62; V, 1.81; U, 1.02 per cent.

Vanadium

The demand for ferro-vanadium was strong during the latter part of the year, both domestic consumption and exports showing increases. The price of ferro-vanadium increased from $2 to $3 per lb. of contained vanadium. Aside from demand the increase of price was possibly also influenced by the high cost of aluminium, which is used by several manufacturers for production of ferro-vanadium.

New Deposits.—Vanadium ore was stated to have been discovered at the Christmas mine, Good Springs, Nev.

Producers.—The chief producers of vanadium ores in 1915 were the American Vanadium Co., the Primos Chemical Co., and the Standard Chemical Co. In additions to these companies there were several manufacturers of ferro-vanadium. The capacity of the reduction plant of the American Vanadium Co. is said to be 30,000 lb. of ferro-vanadium per day.

Metallurgy.—The process for extraction of vanadium from roscoelite has been described as follows.[1] The mill of the Primos Chemical Co. at Vanadium, Colo., treats from 125 to 150 tons daily of ore containing 1 to 3 per cent. V_2O_5. The ore is given a roast with salt and iron sulphide, leaving the vanadium in the form of sodium vanadate which is soluble in water. The iron sulphide is added to aid in keeping a high temperature in the roaster. The roasted ore is leached with weak solution of sodium vanadate followed by hot water. Before precipitation with iron sulphate the solution is cooled with an air jet. The iron sulphate must be present in excess, and 4 to 6 hr. are necessary for complete precipitation. Agitation with air continues for 4 to 6 hr. after precipitation to prevent precipitation of lime. The precipitate of iron vanadate is filtered in a Kelley press and washed with water. After drying it is shipped to the alloy reduction plant.

Bleeker and Morrison[2] have experimented on addition of vanadium to steel in the form of a thermit mixture of V_2O_5, silicon or aluminium, and iron scale. The results indicate that vanadium can be added to molten steel in the form of oxide when mixed with proper reducing agents and

[1] *Min. World*, July 17, 1915, p. 106.
[2] *Met. Chem. Eng.*, August, 1915, p. 492.

slagging materials, and that the total recovery of vanadium in the steel will be higher than when vanadium is made into ferro-vanadium and then added to steel.

Barker and Schlundt[1] worked on the extraction of vanadium from crude sodium uranate. They found four successful methods for accomplishing this.

W. W. Clark[2] states that it is doubtful if small amounts of vanadium will increase the tensile strength of brass and non-ferrous alloys, beyond that due to its powerful de-oxidizing properties, and says that it should not be used as a scavenger because there are a number of cheaper alloys as good for this purpose. However, aluminium-vanadium is considered essential in making copper castings by several of the electrical-machinery manufacturers.

The effect of vanadium in brass was extensively investigated by Dunn and Hudson.[3] They show that the usual structure of brasses containing 50 to 60 per cent. Cu is not greatly modified by the presence of small quantities of vanadium, although alloys containing over 0.5 per cent. vanadium were observed to contain hard bluish enclosures. Up to 1 per cent. vanadium does not appear to effect the structural stability of the constituents of these alloys.

Alloys of vanadium of about the following analyses are being made in the electric furnace:

Ferro-vanadium	Per Cent.
V	35.50
C	0.67
Si	0.23
S	0.02
P	0.02

Aluminium-vanadium	Per Cent.
V	15.1
Fe	0.5
Si	1.0

Vanadium in Peru (By Joseph T. Singewald, Jr., and Benjamin LeRoy Miller).—The vanadium production of Peru comes from the Minasragra mine which is owned and operated by the American Vanadium Co. of Pittsburg. The deposit, which contains much asphalt, had been located several times for coal, but had always been abandoned on account of its high sulphur-content, until in 1905 its vanadium-content was discovered by Antenor Rizo Patron, manager of the Hauraucaca smelter. It was then denounced by E. E. Fernandini, owner of the smelter, and Mr. Patron; and after examination for that company by D. Foster Hewett, was purchased by the American Vanadium Co. Since that time it has furnished 80 per cent. of the world's supply of vanadium, and is capable of furnishing for a long time a much larger tonnage should the demand for vanadium increase. The mine is situated in the department

[1] *Met. Chem. Eng.*, Jan. 1, 1916, p. 18.
[2] *Eng. Min. Jour.*, Oct. 16, 1915, p. 639.
[3] *Metal Industry*, August, 1915, p. 330.

of Junín, about 18 miles by trail west of the Hauraucaca smelter at an elevation of 16,500 ft.

The ore-body is a lens-shaped mass about 300 ft. long and 30 ft. wide lying along a zone of disturbance in a series of gypsiferous shales in which are intercalated a number of beds of gypsum and which have been intruded by a complicated series of igneous dikes ranging in composition from quartz porphyry to diabase. It seems to represent a replacement to a large extent at least of the shales along the zone of disturbance.

The minerals making up the ore-body are patronite, quisqueite, and coke, within which are occasional nests and pockets of pyrite and a small quantity of a reddish-yellow nickeliferous iron sulphide that has been called bravoite. The quisqueite is a black lustrous hydrocarbon and the coke a dull black vesicular one with a much higher carbon-content. The patronite is the vanadium mineral, and is a sulphide of vanadium with a greenish-black color carrying about 20 per cent. vanadium and over 50 per cent. sulphur. Close to the surface the vanadium sulphide has been oxidized and altered to hydrated oxides, ranging in color from red and brown to greenish black.

When the mine was first opened oxidized ores were worked yielding an ore averaging about 20 per cent. V_2O_5. In order to increase the grade of the merchantable ore, attention is now directed to the sulphides alone, which on roasting yield a product with 40 to 50 per cent. V_2O_5. The quisqueite is not removed by roasting so that the amount of it that is present determines the maximum grade of the roasted material. The roasting plant, which was erected in 1909, consists of four hand-operated double-tier reverberatory furnaces with a capacity of 80 tons. The time consumed in passing the ore through the furnace is 2 days. In the heat of the furnace, the ore is self-burning until all but 3 per cent. of the sulphur is expelled, when coal must be added to reduce this to 0.5 per cent. The fuel is a semi-anthracite, packed on llamas from some small neighboring coal deposits.

The figures of vanadium exports from Peru as far as published in the reports on mineral production are:

	Tons.	
1907	351.3	$.......
1908	1,800	345,600
1909	1,749	629,640
1910	3,130	1,141,824
1911	2,249	1,032,000
1912	3,048	720,000
1913	None	None

In 1913 exportation was suspended on account of overstocking the markets in the preceding 2 or 3 years, but in 1914 and 1915 a production of the same order of magnitude as in the previous years was maintained.

ZINC

By R. L. Bartlett

The year of 1915 was one of unparalleled prosperity for the zinc-smelting and zinc-mining industries of the United States, the production eclipsing all previous records, and the prices during the year being such as to bring unexampled prosperity to zinc-mining and smelting districts. With the European production of spelter either stopped entirely, or at least kept from the open market, it was to America that the world turned for the spelter, not only to supply the normal demand, but to furnish the enormous quantities needed for war purposes. Zinc mining was greatly stimulated, and the supply of zinc ore throughout the year was far in excess of the capacity of the smelters. Therefore, the smelting companies were in a position to make most favorable terms for themselves with the ore producers, and while the price of ore reached previously unknown levels, it did not keep pace with the price of spelter, a very large margin of profit going to the smelting companies. Owing also to the insufficient facilities for smelting the ores offered by producers, and the perfectly natural desire on the part of the smelters to fill their retorts with high-grade ore, the producers of low-grade ores could not find so ready a market for their output.

During the year the zinc-smelting capacity of the United States was increased very largely, a great many new plants being erected, and old plants enlarged. The extraction of zinc by electrolytic methods received considerable attention, many experimental and small-sized plants adding materially to the spelter output of the country. The following table compiled by Mr. C. E. Siebenthal of the U. S. Geological Survey shows the location by States of the zinc smelters in the United States, and data as to the retorts used in 1915, and contemplated for 1916. The electrolytic zinc plants are also listed, as well as plants having special retorts.

Notes for table on page 711.
(a) The National Zinc Co. has zinc-roasting furnaces at Argentina, Kans., where the sulphur gases are utilized in an acid plant, the roasted concentrates being shipped to the smelter at Springfield, Ill.
(b) Completed in 1915, but not operated until 1916.
(c) Including furnaces of Owen Zinc Co., operated under lease.
(d) The Prime Western Spelter Co. has roasting furnaces and an acid plant at Tiltonville, Ohio.
(e) The Grasselli Chemical Co. operates acid plants in connection with its zinc-roasting furnaces at Grasselli, Ind., Cleveland, Canton, and Lockland (near Cincinnati), Ohio, and Newcastle, Pa., the roasted zinc concentrates being shipped to the smelters at Clarksburg and Meadowbrook, W. Va.

LIST OF ACTIVE ZINC SMELTERS IN THE UNITED STATES, SHOWING CAPACITY IN 1915, BY COMPANIES AND STATES

[Includes plants working on ore alone, on ore and drosses, and on drosses alone]

Company and State.	Location.	Acid Plant.	Retorts at Close of 1915.	Retorts to be Added in 1916.
Arkansas:				
Fort Smith Spelter Co.	Fort Smith			2,560
Arkansas Zinc Co.	Van Buren?			2,400
Total				4,960
Colorado:				
United States Zinc Co.	Pueblo		2,208	
Illinois:				
American Zinc Co. of Illinois	Hillsboro	A	4,000	800
Collinsville Zinc Smelter	Collinsville		1,792	512
Granby Mining & Smelting Co.	East St. Louis	A	3,220	
Hegeler Zinc Co.	Danville	A	3,600	1,800
Illinois Zinc Co.	Peru	A	4,640	800
Matthiesson & Hegeler Zinc Co.	La Salle	A	6,168	
Missouri Zinc Co.	Beckemeyer		352	
Mineral Point Zinc Co.	Depue	A	9,068	
National Zinc Co.	Springfield	A (*a*)	3,200	640
Robert Lanyon Zinc & Acid Co.	Hillsboro	A	1,840	800
Sandoval Zinc Co.	Sandoval		672	
Total			38,552	5,352
Kansas:				
American Spelter Co. (*b*)	Pittsburg		896	
American Zinc, Lead & Smelting Co.	Caney		(*c*) 7,360	
American Zinc, Lead & Smelting Co.	Dearing		4,480	
Chanute Spelter Co.	Chanute		1,280	
Cherokee Smelting Co.	Bruce		896	
Edgar Zinc Co.	Cherryvale		4,800	
Granby Mining & Smelting Co.	Neodesha		3,760	
Iola Zinc Co.	Concreto		660	
Joplin Ore & Spelter Co.	Pittsburg		1,444	
Pittsburg Zinc Co.	Pittsburg		1,358	
Prime Western Spelter Co.	Gas	A (*d*)	4,868	
United States Smelting Co.	Altoona		3,960	
United States Smelting Co.	Iola		3,440	
United States Smelting Co.	La Harpe		1,924	
Total			41,126	
Missouri:				
Edgar Zinc Co.	St. Louis		2,000	
Nevada Zinc Co.	Nevada		672	
Rich Hill Zinc Co.	Rich Hill			448
Total			2,672	448
Oklahoma:				
Bartlesville Zinc Co.	Bartlesville		5,184	
Bartlesville Zinc Co.	Blackwell			4,800
Bartlesville Zinc Co.	Collinsville		10,752	672
Henryetta Spelter Co.	Henryetta			1,800
J. E. Hildt	Tulsa			3,660
J. B. Kirk Gas & Smelting Co.	Checotah			3,200
Kusa Spelter Co.	Kusa		3,720	
La Harpe Spelter Co.	Kusa			4,000
Lanyon-Starr Smelting Co.	Bartlesville		3,456	
National Zinc Co.	Bartlesville		4,970	
Oklahoma Spelter Co.	Kusa			1,600
Picher Lead Co.	Henryetta			3,200
Tulsa Fuel & Manufacturing Co.	Collinsville		6,232	
United States Zinc Co.	Sand Springs		5,680	800
United States Smelting Co.	Blackwell			6,000
Total			39,994	29,732
Pennsylvania:				
American Steel & Wire Co.	Donora	A	3,648	5,472
American Zinc & Chemical Co.	Langeloth	A	3,648	3,648
New Jersey Zinc Co. (of Pennsylvania)	Palmerton		6,720	
Total			14,016	9,120
West Virginia:				
Clarksburg Zinc Co.	Clarksburg		3,648	
Grasselli Chemical Co.	Clarksburg	A (*e*)	5,760	
Grasselli Chemical Co.	Meadowbrook	A (*e*)	8,592	
Total			18,000	
Total for all States			156,568	49,612

PLANTS WITH SPECIAL RETORTS (a)

Company.	Location.	Retorts at Close of 1915.
Paul Grimm (Inc.)	Trenton, N. J.	9
Michael Hayman & Co.	Buffalo, N. Y.	12
Trenton Smelting & Refining Co.	Trenton, N. J.	96
William Cramp & Sons Ship & Engine Building Co.	Philadelphia, Pa.	32

(a) Large graphite retorts yielding 600–800 lb. of spelter per charge.

ELECTROLYTIC ZINC PLANTS

Company.	Location of Plant.	Daily Spelter Capacity.	Remarks.
American Smelting & Refining Co.	Omaha, Nebr	Experimental	Operated in 1915.
American Smelting & Refining Co.	Garfield, Utah	10 tons	Planned.
Anaconda Copper Mining Co.	Anaconda, Mont	25 tons	Under construction; 10 tons operated in 1915.
Anaconda Copper Mining Co.	Great Falls, Mont	100 tons	Under construction.
Bully Hill Copper Co.	Bully Hill, Cal	Experimental 10 tons	Operated in 1915 Under construction.
Daly-Judge Mining Co.	Park City, Utah	15 tons	Under construction.
Electrolytic Zinc Co.	Baltimore, Md	10 tons	Under construction; 2½ tons now in operation.
Mammoth Copper Mining Co.	Kennett, Cal	Experimental	Operated in 1915.
Northwestern Metals Co.	Helena, Mont	Ore capacity, 100 tons.	Malm process; not operated in 1915.
Reed Zinc Co.	Palo Alto, Cal	Experimental	Operated in 1914–15.
River Smelting & Refining Co.	Keokuk, Iowa	Experimental	Operated in 1915.
Western Metals Co.	Georgetown, Colo	Ore capacity, 100 tons.	Malm process; under construction.

Mr Siebenthal in commenting on the large increase in zinc-smelting capacity of United States, says:

"The number of retorts at zinc smelters has been greatly enlarged in the last year as compared with the year before, increasing from 111,458 at the end of 1913 to 115,114 at the close of 1914, to 130,642 at the middle of 1915, and to 156,658 at the close of 1915. At the beginning of 1916 there was under construction or contemplated additional capacity amounting to 26,992 retorts, which has now been increased to 49,612. When these are completed the total number of retorts will be 206,270, capable of an annual yield under average conditions of approximately 4 tons each, equal to a total of 825,000 tons, if we neglect the number of retorts employed in refining prime western spelter by re-distillation. To this capacity will be added the capacity of the electrolytic zinc plants listed above, over 60,000 tons a year, giving a capacity for the country of about 885,000 tons annually. As if this were not enough, there are reports of still other zinc smelters to be built in Illinois, Missouri, Arkansas, and Oklahoma.

"The abnormal demand for high-grade spelter at present has resulted in the employment of a considerable proportion of the retort capacity of the country in the re-distillation of prime western spelter to improve its grade, but with the resumption of normal conditions these retorts, if operated, will necessarily be put back upon ore. This prediction is rendered certain by the growth in number and size of the plants producing spelter by electrolytic deposition, a list of which is given above. Electrolytic spelter is of high grade, and the recovery is high compared with the production of high-grade spelter by two distillations. The output of electrolytic zinc in the United States in 1915, the initial year of its production, was only 252 tons, but the production is rapidly increasing and by the end of 1916 will undoubtedly reach the rate of over 60,000 tons a year, which, with the output of high-grade spelter from lead-free zinc ores of the Eastern States will be ample to supply the demands for high-grade spelter in ordinary times, thus releasing for ore smelting the retorts engaged in re-distilling prime western spelter.

"At the close of 1916 the spelter-producing capacity of the country, taking into account the capacity for primary spelter listed above, the output of secondary spelter by the large special retorts, and the output of re-melted spelter, will apparently be considerably more than 900,000 tons, or nearly three times the probable domestic demands. The world's consumption of spelter in 1913 was 1,102,456 short tons. It requires no particular insight to recognize that the end of the war, except for a single contingency, will bring about the sudden extinction of a large number of the less advantageously situated smelters. That contingency, which would perhaps justify this abnormal smelting capacity, is the conclusion of arrangements by which in the future practically the whole of the Australian zinc output would be smelted in the United States. In such an event it would seem that smelters fired with producer gas and situated on the Atlantic seaboard, with adjacent markets for acid, would have the advantage over the inland smelters, which have to pay railroad transportation charges, even if such charges are partly offset by the saving involved in using natural gas for fuel."

Production and Consumption Statistics

The following tables, compiled by C. E. Siebenthal and published by the U. S. Geological Survey give the production of primary and secondary spelter in the United States, consumption of primary spelter in the United States, as well as exports and imports of zinc ores, and products containing zinc.

PRODUCTION OF SPELTER IN 1915
(In tons of 2000 lb.)

	1914.	1915.	Change in 1915. Quantity.	Change in 1915. Per Cent.
Production of primary spelter[a] in United States.	353,049	489,519	136,470	39
Consumption of primary spelter in United States.	299,125	364,382	65,257	22
Value of primary spelter produced in United States	$36,011,000	[b]$121,401,000	$85,390,000	237

a Primary spelter is made directly from ore, but secondary spelter is recovered from such sources as drosses, skimmings, and old metals.

b Value calculated from average selling price.

PRODUCTION OF PRIMARY SPELTER IN THE UNITED STATES

Apportioned according to source of ore

United States:	1910.	1911.	1912.	1913.	1914.	1915.
Total domestic	252,479	271,621	323,907	337,252	343,418	458,135
Foreign:						
Canada	3,304	1,598	4,199	1,424	4,538	5,103
Mexico	13,401	13,307	10,700	6,205	5,093	13,943
Europe	....	......	....	1,175	....	1,073
Asia	....	......	....	620	....	1,030
Australia	....	......	....	....	....	10,235
Total foreign	16,705	14,905	14,899	9,424	9,631	31,384
Grand total	269,184	286,526	338,806	346,676	353,049	489,519

Apportioned according to locality in which smelted

	1910.	1911.	1912.	1913.	1914.	1915.
Illinois	73,038	83,130	88,397	106,654	127,946	159,958
Kansas	105,697	98,413	101,104	74,106	44,510	100,983
Oklahoma	34,760	46,315	76,925	83,214	91,367	109,208
Other States	55,689	58,668	72,380	82,702	89,226	118,930
Total	269,184	286,526	338,806	346,676	353,049	489,519

PRODUCTION OF SECONDARY ZINC IN THE UNITED STATES

	1910.	1911.	1912.	1913.	1914.	1915.
Secondary spelter, re-distilled	12,784	14,043	26,064	25,991	20,545	29,764
Secondary spelter, re-melted	28,439	26,470	26,187	24,014	22,424	[c]22,200
Recovered zinc in alloys, excluding old brass re-melted	2,709	3,223	3,912	3,743	3,914	[c]5,300

c Subject to final revision.

CONSUMPTION OF PRIMARY SPELTER IN THE UNITED STATES

	1910.	1911.	1912.	1913.	1914.	1915.
Supply:						
Stock, Jan. 1—						
In bonded warehouses	39	31	32	48	....	111
At smelters	11,167	23,201	9,049	4,474	40,659	19,984
Production—						
From domestic ore	252,479	271,621	323,907	337,252	343,418	458,135
From foreign ore	16,705	14,905	14,899	9,424	9,631	31,384
Imports	1,960	609	11,115	6,100	880	904
Total available	282,350	310,367	359,002	357,298	394,588	510,518
Withdrawn:						
Exports, foreign, from warehouse	4,758	11,276	6,286	6,027	5,580	13,720
Exports, foreign, under drawback	4,486	3,079	1,219	7,459	4,981	367
Exports, domestic	3,990	6,872	6,634	7,783	64,807	117,796
Stock, Dec. 31—						
In bonded warehouses	31	32	48	....	111	32
At smelters	23,201	9,049	4,474	40,659	19,984	14,221
Total withdrawn	36,466	30,308	18,661	61,928	95,463	146,136
Apparent consumption	245,884	280,059	340,341	295,370	299,125	364,382

EXPORTS OF DOMESTIC ZINC ORE AND DROSS

	1910.	1911.	1912.	1913.	1914.	1915.
Zinc ore	19,711	18,281	23,349	17,713	11,110	832
Zinc dross	4,729	4,246	205	28	2,526	4,167

IMPORTS OF ZINC ORE

	1910.	1911.	1912.	1913.	1914.	1915.
Zinc ore	72,626	39,116	43,940	31,416	31,962	158,852
Zinc content	25,439	15,933	17,567	13,497	12,132	57,669

NOTE.—Imports and exports of spelter are given under the heading "Consumption." The imports of spelter in 1909–1915 are as given in the December Summary of the Bureau of Foreign and Domestic Commerce except that for 1909–1912, inclusive; the quantities given therein have been diminished by the quantity of zinc dust imported since Aug. 6, 1909, for the reason that the imports of spelter and zinc dust for that period were not separated in the Summary. The imports of spelter do not include sheet zinc, but include a few hundred tons of old zinc, fit only for re-manufacturing. The stock in bonded warehouses does not include zinc ore in bond or the spelter made therefrom, such spelter being included in stock at smelters.

EXPORTS

Exports of lead and zinc from the United States by 6-month periods, 1914–1915, by classes, in pounds

	1914.				1915.			
	January–June.		July–December.		January–June.		July–December.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Domestic:								
Zinc ore	16,083,200	$275,184	6,137,600	$113,280	1,355,200	$24,791	309,120	$10,485
Spelter and sheets	1,659,858	100,657	127,954,164	8,440,011	128,735,815	11,627,295	106,856,700	17,618,699
Zinc dross	572,477	29,084	4,498,590	128,860	5,863,250	345,387	2,470,263	161,569
Zinc manufactures	....	82,254	....	128,654	....	1,047,975	....	1,125,114
Brass, old, for re-manufacturing	13,535,666	1,437,763	7,103,735	663,107	8,662,272	912,896	2,594,400	346,742
Brass, bars, plates, and sheets	3,084,938	443,187	4,030,869	465,966	36,251,304	5,683,217	30,020,806	6,752,689
Brass, articles made from	....	1,862,515	....	1,894,373	....	10,924,990	....	30,192,781
Cartridges	....	1,896,415	....	4,670,707	....	13,043,498	....	11,771,181
Lead, pigs and bars	40,323,662	1,511,800	77,120,238	2,989,874	115,903,983	4,936,730	58,280,194	2,860,268
Lead manufactures	....	633,234	....	385,000	....	732,875	....	1,538,022
Foreign:								
Zinc ore, contents	279,000	5,909	....	....	....	....	....	....
Zinc blocks, pigs, and old	55,118	2,634	10,825,453	209,602	11,408,033	336,399	16,032,910	2,110,571
Zinc dust	34,212	1,775	322,050	15,697	227,408	22,680	204,407	32,707
Zinc manufactures	....	53	....	18,491	....	54,124	....	64,980
Brass, old, for re-manufacturing	12,585	1,586	1,068	135	....	....	....	....
Lead ore, contents	6,724,525	245,205	....	....	....	....	....	....
Bullion, contents	10,944,350	378,286	....	....	....	....	....	....
Lead, pigs and bars	....	....	25,421,500	913,306	34,447,599	1,042,141	42,455,113	1,690,151
Lead manufactures	....	1,810	....	432	....	31	....	40,081
Lead used in articles exported with benefit of drawback	7,595,127	[1]301,500	11,416,486	[1]431,500	6,040,015	[1]262,700	1,926,287	[1]90,535
Zinc used in articles exported with benefit of drawback	3,761,879	[1]198,400	6,200,279	[1]330,500	[1]510,678	[1]65,000	223,052	[1]27,658
	....	9,409,251	....	21,882,495	....	51,062,729	....	76,434,233

[1] Represents the value of the metal used in making the articles exported with benefit of drawback.

Exports of zinc from the United States, by 6-month periods, 1914–1915, by destination, in short tons

Destination.	Spelter and Sheet Zinc.							
	1914.				1915.			
	January–June.		July–December.		January–June.		July–December.	
	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.
Canada	....	167	3,383	539	2,918	382	6,561	203
Great Britain	45	....	40,802	2,897	31,100	3,477	23,452	1,644
Netherlands	....	....	....	....	....	....	12	....
Belgium	....	....	....	....	....	....	....	....
France	....	....	8,463	1,902	15,849	1,396	9,406	4,668
Italy	....	....	1,651	....	2,717	448	6,051	504
Germany	84	....	....	....	....	....	....	....
Russia	667	....	4,152	....	6,671	....	5,420	....
Japan	....	....	456	....	187	....	470	....
Other countries	34	....	5,070	75	4,926	....	2,256	997
	830	167	63,977	5,413	64,368	5,703	53,428	8,016

Exports of zinc from the United States, by months, 1914–1915, in short tons

Month.	Spelter and Sheet Zinc.		
	Domestic.	Foreign.	Foreign Zinc Used in Articles Exported with Benefit of Drawback.
1914.			
January	230	28	
February	18	....	
March	146	....	1,881
April	60	....	
May	107	112	
June	269	27	
July	157	....	
August	3,448	319	
September	19,045	1,120	
October	10,259	1,140	3,100
November	12,747	957	
December	18,321	1,877	
	64,807	5,580	4,981
1915.			
January	15,299	84	
February	15,002	2,016	
March	8,120	1,136	
April	8,842	77	255
May	7,635	1,104	
June	9,470	1,286	
July	5,981	1,876	
August	6,938	757	
September	8,653	2,122	112
October	12,133	608	
November	10,019	2,343	
December	9,704	310	
	117,796	13,719	367

It is interesting to study the figures of spelter production by quarters, and note the effect of the increasing prices and smelting capacity on the output of the different districts.

PRODUCTION OF SPELTER BY QUARTERS[1]

(In tons of 2000 lb.)

Reports of ore smelters only

District.	I.	II.	III.	IV.
1913.				
Illinois	27,924	28,523	26,118	28,986
Kansas-Missouri	22,006	23,820	19,204	20,127
Oklahoma	21,430	21,840	18,502	21,458
Others (a)	20,722	20,153	19,238	18,211
Totals	92,082	94,336	83,062	88,782
1914.				
Illinois	31,005	32,482	32,512	34,584
Kansas-Missouri	13,939	14,659	13,193	11,633
Oklahoma	22,563	22,960	22,945	23,999
Others (a)	22,717	22,715	24,106	24,296
Totals	90,224	92,816	92,756	94,516
1915.				
Illinois	35,786	39,511	41,791	44,577
Kansas-Missouri	14,090	24,554	32,152	40,256
Oklahoma	24,713	26,984	28,613	31,095
Others (a)	26,255	30,575	31,360	34,830
Totals	100,844	121,624	133,916	150,758

(a) With the exception of one plant in Colorado these are all Eastern works. In the fourth quarter of 1915 is included Anaconda production.

[1] W. R. Ingalls, *Eng. Min. Jour.*

The production of spelter by quarters showed a steady increase, especially in the second quarter, when the important new plants of 1914—Rose Lake and Langeloth—began to strike their gait, when several of the older smelters began to get new furnaces in operation, and when the resumption of work in several previously idle plants—especially Caney, Dearing and Altoona—began to count largely in the production. In the third quarter several of the small coal smelteries of olden times, one or two new ones and some of the older, almost forgotten, natural-gas plants began to come in. In the fourth quarter the new plants, whereof the construction was instituted in 1915, began to figure, especially Kusa, Donora and Owen, and some of the older plants that had been enlarged—such as Sand Springs, Meadowbrook and one of the Iola works—contributed to the swelling of the output.

However, the total addition of the large new plants—like Kusa and Donora—to the production in 1915 was relatively small. Up to the end of the year they had succeeded in getting but comparatively few furnaces into operation, but had arrived at a position whence they would progress rapidly. Another group of new plants was about ready to come in. This portended a further increase in production in the first quarter of 1916.

Spelter Production According to Fuel.—Of the total spelter production of the ore smelters in 1911, concerns using coal as fuel produced 119,989 tons, or about 40 per cent. of the total. In 1912 they produced 134,077 tons, which was only about 38 per cent. of the total. In 1913 their production was 157,653 tons, or about 44 per cent. of the total; in 1914 it was 173,520 tons, or about 48 per cent. of the total. The remainder of the production was made by smelters using natural gas as fuel. Up to 1915 there was a general tendency toward increasing production by the smelters using coal as fuel, their proportion of the total output having risen from 40 per cent. in 1911 to 48 per cent. in 1914. In 1915 it fell to 45 per cent., in spite of the revival of smelting at Pittsburg, Kan., which is easily explained. There were a lot of inactive natural-gas smelteries that could be put quickly into operation, which was done, and moreover, it was quicker and easier to build new plants in the natural-gas fields than in the coal fields.

General Conditions of Ore Supply.—The outstanding features of 1915 were the extraordinary increase in the production of Montana, the large increases in those of New Jersey, Idaho, and Tennessee, and the generality of the increase among nearly all of the other States. Colorado was the only important State to show a decrease, and that may not really have been experienced, for the reason that Colorado ore may have gone to oxide manufacturers rather than to smelters. Even more interesting is the extraordinarily large importation of foreign ore, which came most largely from Broken Hill, N. S. W., and next largely from Mexico. The magnitude of the Mexican imports is surprising in view of the political troubles existing in that country. Included in the ore receipts from other foreign countries was a considerable quantity from the north of Africa and from China. Lately ore has been coming from Sardinia.

The reports as to ore receipts give some interesting indications as to practice in smelting and as to marked conditions. The smelters who make sulphuric acid continued, as in the past, to draw their ore mainly from Wisconsin, and from the Joplin district (including Oklahoma). For the manufacture of sulphuric acid this ore is recognized to be superior, but it is noteworthy that several of the zinc-acid makers are using a larger and larger proportion of Western ore. An interesting feature of 1915 was that the major part of the new smelters—not making acid—confined themselves to Joplin ore. Apparently they desired to begin with the kind of ore easiest to smelt. All told, there were 11 smelters in 1915 who used nothing but Joplin and Wisconsin ore and 7 smelters who used none of that ore.

Those smelters who did not figure in the Joplin market were chiefly concerns whose geographical position does not permit them to do so; or concerns that make a specialty of smelting calamine, or who in 1915 confined themselves to calamine for other reasons. Without examining this matter very closely, one gets the impression from the statistical reports that the zinc smelters figured more generally in the Joplin market than they had done for several years previous. This is explained by several considerations. New concerns entering the smelting business in Kansas and Oklahoma would naturally take Joplin ore, which is relatively easy to smelt, while the successful handling of the Western ores requires a good deal of experience. A matter of more importance and one that attracted the older smelters back to the Joplin market was that the Joplin market was the easiest in which to do business. It was a spot market, where the buyer could obtain his ore immediately, and where he was under no obligation to buy if he did not want to. This relieved him from the onus of taking in ore on long-time contracts, the prevailing system with respect to Western ores, which became highly dangerous with the conditions existing in the spelter market in 1915.

In 1915 Australian ore was received at 10 smelteries, the major part of which were east of the Mississippi River, but several of which were in Oklahoma and Kansas. There were 7 smelteries at which practically nothing but calamine was used. In some cases this was attributable to the special practice of the smelters operating these works; in others it was for the reason that the roasting furnaces of new plants were not ready and it was easiest to begin smelting in this way.

Ore Smelted.—The smelters reported that in 1915 they treated 848,776 tons of blende and 349,299 tons of calamine, a total of 1,188,075 tons. In 1914 they smelted 628,886 tons of blende and 226,549 tons of calamine, a total of 855,435 tons. That a larger proportion of calamine was being smelted was the common conjecture during the year. Calamine was sought especially for the reason that roasting furnaces are not necessary for its treatment, and even in 1914 American zinc smelters were short in roasting capacity, as was pointed out in the *Engineering and Mining Journal* of Feb. 27,1915. An average grade of 50 per cent. for the ore smelted is indicated in both years. Offhand it might have been assumed that the average in 1915 would figure lower than in 1914, for the reason that the high price tended to stimulate the production of low-grade ore. In so far as the miner is concerned that was probably the case, but about all zinc ore has to be concentrated anyhow, and it is always desirable to raise the grade as high as possible. Certain important producers allowed the grade of their product to fall off a little in order to get more through their mills, but this was apparently offset by the high-grade ore that the smelters were able to get from other quarters. On their part the smelters wanted high-grade ore in order to make as much spelter as possible, and the ore supply was so bountiful that they could exercise considerable choice as to what they would take.

In 1914 the production of floated blende concentrate was nearly 100,000 tons. This increased in 1915, having been in the neighborhood of 250,000 tons. The good handling of this troublesome material is one of the present great problems of the smelters, but in view of the importance of the flotation process they simply have to solve it. About 100,000 tons of American spelter, not counting any derived from Australian material, was obtained from floated concentrates in 1915.

Receipts of Ore.—In 1915 the smelters received 1,257,528 tons of ore, compared with 872,767 tons in 1914. The sources of the ore receipts for a series of years are shown in the accompanying table. This table gives the ore receipts reported as taken in by the smelters, distributed according to origin. This is not equivalent to the ore production of the several States, inasmuch as ore that went to the zinc-oxide plants at Coffeyville, Kan., Mineral Point, Wis., and Palmerton, Pa., is not included. For this reason the ore received by the smelters of spelter from New Jersey (included in "other States"), Colorado, New Mexico and Wisconsin was considerably less than the outputs of those States.

With those exceptions, however, the figures in the table probably correspond closely with the productions of the several States.

RECEIPTS OF ZINC ORE

(In tons of 2000 lb. This table includes the receipts of ore by the smelters only and does not include the production of ore exported or what was taken by the manufacturers of zinc oxide)

State.	1910. (*a*)	1911. (*a*)	1912.	1913.	1914.	1915.
Arizona	7,568	6,395	11,937	9,347	6,357	14,718
Arkansas	190	860	1,567	1,500	1,737	7,017
California	(*d*)	3,754	6,639	6,796	8,827	27,445
Colorado	77,065	158,528	212,423	220,166	164,739	148,359
Idaho	10,248	9,667	19,482	31,835	57,001	78,767
Kentucky	179	575	947	441	434	1,863
Missouri-Kansas	289,913	268,500	289,177	280,000	247,723	278,099
Montana	33,514	56,593	34,034	91,257	125,663	200,528
Nevada	4,915	5,666	20,654	22,313	20,447	24,949
New Mexico	15,959	10,184	25,889	14,593	15,369	37,042
Oklahoma	1,640	8,750	4,325	23,500	25,247	25,231
Tennessee	2,775	3,439	6,635	8,297	18,708	38,527
Utah	27,318	19,933	24,539	27,073	20,322	21,535
Wisconsin (*b*)	51,383	71,565	90,762	89,662	71,311	90,128
Others	46,905	44,896	56,099	57,241	57,936	122,490
Totals	569,572	669,305	805,109	884,021	845,821	1,116,698
Mexico	29,198	28,596	29,436	19,965	16,414	49,171
Canada	11,795	2,356	9,707	6,012	10,532	14,000
Australia	....	....	....	....	....	68,448
Other foreign	....	....	....	....	....	9,211
Grand totals (*c*)	610,565	700,257	844,252	909,998 (*c*)	872,767	1,257,528

(*a*) Smelters' receipts: reports missing from three small smelters. (*b*) Including Illinois and Iowa. (*c*) In addition to the ore reported from Canada and Mexico, zinc smelters received a few thousand tons from Europe and Eastern Siberia in 1913. (*d*) Included in "Others."

The aggregate of ore receipts was much larger than the aggregate of the ore smelted. This was also the case in 1914. However, in 1915 the excess was very much larger. The explanation of this feature in both years is of course the stocking up of new plants. In 1915 this was a very important factor in view of the large number of new plants that were put into operation. In certain cases, as for example, Langeloth, Tiltonville and Donora, this is a permanent absorption. In other cases, where new plants were put into commission in 1915 with the probability of only ephemeral operation, their stock of ore will some day be released.

Sulphuric Acid.—In 1915 there were 10 smelters who produced sulphuric acid from blende, the Donora Zinc Co. being an addition to the list. It is often good business to roast the blende at a good center for the distribution of the sulphuric acid, and re-ship the roasted ore to a good point for zinc distillation. The Western Chemical Co. has for a long time roasted ore at Denver Colo., and sold the product to smelters. The National Zinc Co. has no roasting furnaces at its smeltery at Springfield, Ill., which gets its ore from the roasting plant of the company at Argentine, Kan. Similarly the Grasselli Chemical Co. roasts at Canton, Cincinnati, Newcastle, Cleveland and Grasselli the ore that is needed by its smelteries at Clarksburg and Meadowbrook. The New Jersey Zinc Co. has a roasting plant at Tiltonville, Ohio, which supplies other smelters. With the movement of the zinc smelting industry to the eastward, the separation of blende roasting and zinc distillation is becoming more marked, as it has been for a long time in Europe. It will appear from this that the definition between zinc smelters' acid and acid derived from other sources is becoming more and more uncertain.

The manner in which spelter production in 1915 was expanded is one of the romances of our industry. The incentive to this was of course the enormous profit to be realized.

It must be clearly understood that the high prices of 1915 were determined by an extraordinary demand, insistent, and indifferent as to what had to be paid; and to a deficiency of supply that was due to shortage of smelting capacity, not of ore. The high prices were paid therefore for the use of smelting capacity. There was at all times a plethora of ore, and the price for the latter rose therefore in far less proportion than did that of spelter; in other words, the smelting margin increased and did in fact attain such figures as $50 or $60 per ton. It being thus a smelters' market, miners found difficulty in placing their ore at all. The Butte & Superior company consequently made arrangements with the American Zinc, Lead and Smelting Co. for re-opening the Caney and Dearing smelteries. The United States Smelting Co., in order to dispose of ore production of its own, purchased the old plants at Altoona, Iola and La Harpe. When the purchase was made, it looked like a very hazardous venture. Even more so looked the enterprise of George E. Nicholson, when he started the construction of a big new plant at Kusa, which could not even begin production until late in the year. Much less risky was the program of the United States Steel Corporation in building at Donora, for that company as the largest consumer of spelter was planning a permanent business. In this case, however, a wonderful record in construction was made. For the building of such a plant about 18 months would ordinarily be reckoned. At Donora, ground was broken about the end of June and the first spelter was made on Oct. 20. However, the plant could not be regarded as completed until about Mar. 31, 1916, and considering that the construction was carried on night and day, with all of the great facilities of the Steel Corporation, the actual time of 9 months is not greatly out of tune with the common estimate of 18 months, but this is not to minimize the really remarkable feat of the Donora engineers.

As time wore on and people became used to the idea of phenomenal prices for spelter and as the market failed to show signs of collapse, the building of new plants was commenced on all hands. At the present writing—the end of March, 1916—they are springing up like weeds and it is almost useless to try and enumerate them. What then of the future? Simply that the shortage of smelting capacity is bringing about its own correction.

Reverting once more to the statistics of spelter production in 1915, there are three very remarkable features. The first is the enormous total. Next is the rapid gain in production, quarter by quarter. In the last quarter of 1914 the production was about 94,500 tons. The production of the first quarter of 1915 advanced by about 5000 tons; the second quarter by about 20,000 tons, this being the quarter when the old idle works were restored to operation; the third quarter by about 12,000 tons; and the fourth quarter by about 17,000 tons. The third noteworthy feature is that the great new plants, including Kusa and Donora, produced but little spelter in 1915. However, at the very end of the year they were just about beginning to strike their gait. Increasing outputs in the first and second quarters of 1916 therefore are to be anticipated without taking into consideration any more new plants.

In fact, at the end of 1915 the listed smelters of the United States possessed a total of about 155,000 retorts, and all of them were reported in use at that time. Reckoning a production of 4.2 tons of spelter per annum per retort, the rate of production at that time was 650,000 tons per annum, or 162,000 tons per quarter. Besides that there were 23,234 retorts reported in process of building at the end of 1915, this number corresponding to an output of about 97,500 tons of spelter per annum.

As if this were not enough, there was the Trail production of electrolytic spelter at the rate of about 12,000 tons per annum, scheduled to begin in January, the Anaconda production at the rate of 35,000 tons per annum, expected to begin late in the summer, and a certain production at Garfield, Utah. The total production in prospect was, therefore, 794,000 tons per annum. There were enough odds and ends in sight, but not enumerated, to justify talking about a total of 800,000 tons per annum, even at the beginning of 1916. Since then the prospect has been materially enlarged.

High-grade Spelter.—One of the noteworthy features of 1915 was the special demand for intermediate and high-grade spelter. Prices of 30 to 40 cts. per lb. for those sorts led several concerns to enter upon their manufacture besides the New Jersey Zinc Co., which previously had possessed substantially a monopoly of this business. The new concerns entered this market by the smelting of selected ore and by the re-distillation of common spelter. It would have been interesting to have had statistics of production of spelter according to class, so as to have some measure of the magnitude of the market for the high-grade and intermediate sorts, but the smelters who were engaged in this manufacture were averse to such a disclosure.

Spelter Prices during 1915

When we consider the enormous increase in the price of spelter above what formerly had been considered a fair price, the cause for the record production of ore, and of spelter is readily apparent. We find that spelter opened at St. Louis in January at 5.7 cts. per lb. and immediately began rising, except for one setback in March and a smaller one in May, until the first week in June, at which time it touched the high level of the year at 27.2 cts. per lb., or about five times the price at the beginning of the year. A sharp drop took the price to about 18 cts. by July 10, followed by a slight rally, and another drop to about 12 cts. by the middle of August. From this time numerous fluctuations were noted, but the year closed with spelter quoted at 17.3 cts. per lb. The *Engineering and Mining Journal* in commenting on prices, says: At the beginning of 1915 the price for common spelter was about 5.60, St. Louis. As stocks became exhausted, prices varied widely according to delivery. Considering the contracts that covered the bulk of the sales, the high point was touched on June 4 with a quotation of 24 @ 27 cts. At the end of the year the quotation was 15¼ @ 16¾ cts. The highest monthly average was in June, when it was 21.038 cts. The average for the year was 13.054 cts. The reports of one or two companies that have published their results for the year indicate that the average of all sales fell somewhat short of the quotational average. According to Mr. Zook the average of 60 per cent. ore at Joplin was $54.25 in January, $108.30 in June (high mark) and $98 in December, the average for the year being $81.57. Compared with the price for 1000 lb. of spelter at St. Louis, these figures indicate a smelting margin of about $8 in January, $102 in June, $54 in December, and $49 for the year.

Owing to the extraordinary conditions created by the great war and the uncertainty at the present time regarding the outcome of the struggle, or the economic conditions which will prevail in these countries, no one feels able to predict the price of spelter far in advance, although the general impression seems to be that high prices will last throughout 1916. Some authorities claim that with the return of peace, the supply of spelter will be way ahead of the demand, with a very low level of prices prevailing. One of the principal factors to be taken into account is the disposition that will be made of the Broken Hill ores from Australia after the war. While some of these are coming to America, and some to England, the major part is being stored in Australia, and should Germany and Belgium resume the smelting of these ores after peace is declared, it can not but affect the American zinc-smelting industry adversely.

While ordinary brands of spelter have commanded a phenomenal price, the price for so-called "high-grade" spelter has been even higher, rising in some cases to 40 cts. per lb., owing to the great demand for exceptionally pure brass for cartridge manufacturing. In discussing the grades of spelter, the *Engineering and Mining Journal* says:

Previous to the war there was an official classification of virgin spelter as high-grade, intermediate, brass special and prime Western. High-grade spelter had to contain at least 99.9 per cent. zinc and intermediate from 99.5 to 99.9 per cent., besides conforming to certain specifications respecting the contents of lead, iron and cadmium. The only high-grade spelter was the well-known Horsehead and Bertha brands, and there was but a limited market for them. By restricting the production to the relatively small demand a premium of about 2½ cts. per lb. was realized for these brands on the average.

Soon after the war began, an extraordinary demand for spelter of this kind arose, and in 1915 a price as high as 40 cts. per lb. was received, which was about 15 cts. per lb. above the maximum for prime Western. The classification of intermediate spelter was practically wiped out, a range of 0.5 per cent. in zinc-content being too wide. Spelter assaying 99.8 to 99.9 per cent. zinc fetched one price, that assaying 99.7 to 99.8 another, and so on. In fact, there developed a market for high-grade spelter, for high-grade intermediate, for lower grades of intermediate, and thus downward. Until recently the Horsehead and Bertha brands continued to be the only high-grade spelter, strictly speaking, although the high-grade intermediate was commonly referred to as such. Lately the Mascot brand, produced from Tennessee ore, has been put in the high-grade class by refinement of methods of production.

The high-grade intermediate spelter is produced by the smelting of ore selected for its purity—especially its freedom from lead—or by the re-distillation of common spelter. In either case the impurity that is particularly difficult to control is cadmium. Most of the spelters that analyze about 99.85 per cent. in zinc are equal to the high-grade specifications in the matters of lead and iron, but are a little too high in cadmium.

Now whether cadmium is a deleterious element in spelter, or not, is a moot point, even with regard to a considerable proportion of it. For many purposes—even military purposes—it is inconceivable that 0.05 per cent. Cd, plus or minus, can make any great difference. About 10 years ago, some manufacturing experiments made by a well-known brass maker indicated that for ordinary brass cadmium is not a deleterious element. Since then Mr. Rigg and his colleagues in the New Jersey Zinc Co. have indisputably shown that cadmium—even in small proportion—is highly objectionable in spelter that is to be used in making slush castings. It is pretty well established, moreover, that for making cartridge brass the spelter should be as pure as can be obtained, for otherwise the cartridge cases deteriorate in course of time. The quality of the brass is not apparently so important in the case of cartridges that are to be used soon.

Let the influence of cadmium in spelter be what it may, there is no doubt that military specifications have called for spelter much more highly refined than is necessary in many cases. However, discussion of this is purely academic. Some users of spelter have cadmium on the brain and are willing to pay 5 cts. or so per pound of spelter for the difference between 0.1 per cent. Cd and 0.05 per cent. Cd, and the rational thing for zinc producers to do is to give them what they want and take their money. There is no use in arguing with them that they ought not to want what they think they do.

Whether it be high-grade spelter or high-grade intermediate, the preposterous premium had the natural effect of stimulating the production of those kinds, and of course, the additional supply will sooner or later reduce the premium. Of late these sorts of spelter have not been so readily salable as they were a little while ago. Some of the producers, averse to recognizing any change in the conditions and hopeful that they will once more be able to sell their product at the price for tin, are holding it back. Such accumulation of unsold spelter as is now believed to be taking place is supposed to be chiefly of these kinds. One of the reasons for the sustained strength in the market for prime Western is the diversion of so large a proportion of it to the manufacture of refined. The advent of new producers of superior spelter will naturally hasten the correction of the disparity in prices that has existed for so many months.

Spelter and Other Coating Metals.—The abnormally high prices for spelter during the past year have greatly reduced the amount of zinc used by the galvanizers, and caused them to either greatly curtail their output of galvanized iron, and in many cases to try to substitute some other coating metal for the zinc. For roofing purposes the various prepared roofings, which have been serious competitors of galvanized iron in the past, made great inroads into the trade. Painted sheet steel was substituted by many mills for supplying their trade. Lead-coated steel sheets are being made, and with the impetus given by the high spelter prices it is probable that this industry will become of considerable importance. Another point to be mentioned is that with spelter at the present level of prices tin plating actually costs less per square foot than does galvanizing, and in many cases is being substituted. Thus we find that the abnormal prices prevailing for spelter have greatly crippled the galvanizing trade, and it is quite probable that the use of zinc for this purpose may not in the future regain the importance it held before the war, owing to the many substitutes developed by reason of necessity at the present time.

Zinc Mining in the United States

Arizona.—Zinc production in Arizona for 1915 was almost double that of 1914, or about 8000 tons of spelter. Most of this production came from the Golconda and Tennessee mines in Mohave County, the former producing about $250,000 worth of gold and zinc per month. Some shipments were also made from Pearce and Hereford, in Cochise County; Casa Grande, in Pinal County; Red Rock in Pima County; and Crown King in Yavapai County. The Texas Arizona property in the Cochise district, and the Duquesne property in Santa Cruz County, also shipped ore.

Arkansas.—The output for 1915 was 7700 tons of zinc ore, worth $1,000,000. This was obtained from 87 mines. The carbonate and silicate ores amounted to nearly 7000 tons of this amount, of which 3420 tons was shipped without milling. The counties figuring in this production are Boone, Baxter, Marion, Newton, and Searcy.

California.—The Mammoth mine, near Kennett, Shasta County, was a large producer during the year, as was also the Cerro Gordo mines of Inyo County, the latter producing 4200 tons of zinc. As the output for 1914 was only 159 tons for the whole State, it is readily seen what a stimulus has been given to the recovery of zinc by the high spelter prices. At Bully Hill much work has been done on electrolytic smelting for refractory zinc ores.

Colorado.—The output of zinc was somewhat greater than for 1914, most of it coming from Lake County, of which Leadville is the principal mining town. While the grade of the carbonate ores fell off somewhat, there was excellent demand at high prices for them. The output of sulphide ores showed an increase in both grade and quantity. Owing to the smelting capacity of the country being greater than the roasting capacity, carbonate ores were in especial favor. However, Colorado did not make the enormous strides in production which other States are credited with.

Idaho.—The Consolidated Interstate Callahan mine continued its rapid increase in production of zinc ore, and in 1915 ranked third among zinc-producing companies, being exceeded only by the New Jersey Zinc Co., and the Butte & Superior Co. In the Coeur d'Alene district ore was developed in the Prichard formation, which promises to greatly extend the district. Nearly all the mills of this district are now equipped with flotation units. Taken as a whole the zinc industry has been greatly stimulated by the high prices ruling during the year.

Missouri (Joplin District) (By Jesse A. Zook).—A review of the market price of blende, a zinc sulphide ore, and of calamine, a zinc silicate-carbonate ore, during the year 1915 reads like a fable. The year opened with a high price of $54.50 per ton for blende, and January closed with what was then thought a phenomenal rise to $67.50, or $13 in one month. February noted a further advance to $76, then a reaction to $63 the latter part of March and early April, that month closing at $68, followed with $88 in May. Here came the pyrotechnical display of the year, with advances in 2 weeks to $138.90, a lift of $50 in a fortnight, $70 in a month and $84 in 4 months. All previous records of high prices floated away as an iridescent dream, and there was no doubt in the minds of many that $200 per ton would be realized within another month. A guessing contest, originated at this time, brought out guesses up to $500 per ton. The next week it dropped to $131. No one believed it could possibly stay down, but again it dropped, this time to $112.50. Then the price was sliced off $40 more in the next 3 weeks, striking a low level of $72.50 per ton the third week of August, a drop of $66 in 2 months. That was the end of big reverses, and the price climbed to $89 the first of September, ending the month at $82.50, rose to $90 the first of October, back to $87.50, up again at the close to $93, then to $102.50 one week, $112.50 one week and $118 the latter 2 weeks of November, closing the year at $116.50.

JOPLIN DISTRICT ORE SHIPMENTS, IN POUNDS, 1915

Missouri:	Blende.	Calamine.
Jasper County	449,280,070	5,063,910
Newton County	32,234,170	35,747,950
Green County	4,013,900	....
Lawrence County	1,882,640	8,045,510
Dade County	....	2,157,000
Total Missouri	487,410,780	51,014,370
Oklahoma:		
Ottawa County	53,399,530	230,280
Kansas:		
Cherokee County	56,899,670	113,000
Total, 1915	597,669,980	51,357,650
Total, 1914	510,787,430	39,031,880
Increase	386,912,550	12,325,770

The production of calamine assumed an importance undreamed of in past years, as prices of this mineral rose from $23 base of 40 per cent. zinc, with the opening of the year, to $40 in March and $80 in June. While the price declined through July and August, along with blende, it was less severe, at no time receding below $50, and advancing again to $80 in November.

ORE PRICES IN JOPLIN DISTRICT
(15 Years)

Year.	Zinc Ore.	
	High.	Average.
1901	$34.00	$24.21
1902	42.00	30.33
1903	42.00	33.72
1904	53.00	35.92
1905	60.00	44.88
1906	54.00	43.30
1907	53.50	43.68
1908	47.00	34.36
1909	55.00	41.08
1910	52.00	40.42
1911	51.00	39.90
1912	67.00	53.33
1913	59.00	42.26
1914	54.00	40.46
1915	138.90	79.30

For the first time in the history of the district, the production of calamine was taken over by men of big business instincts, and the Granby camp was exploited in a business-like manner. Shipments grew under able mine prosecution from a few carloads the first of the year to upward of 30 carloads per week at the close. The demand of smelters for ores of certain grades being learned by these big producers of calamine, they withheld their ore from market during the periods of low-price level. This maintained a firm calamine price for the producer of small quantities.

AVERAGE MONTHLY ORE PRICES

	Zinc Ore.					
	Joplin Base.		Joplin All Ores.		Platteville.	
	1914. $	1915. $	1914. $	1915. $	1914. $	1915. $
January	40.63	54.25	38.71	51.01	50.09	54.88
February	42.50	67.38	41.15	65.93	42.63	69.00
March	38.88	64.80	38.54	62.73	40.13	64.10
April	38.55	62.75	36.75	56.03	39.25	57.25
May	39.31	73.13	36.68	69.42	39.25	66.88
June	39.63	108.30	38.41	101.84	39.75	107.00
July	38.95	104.63	35.58	104.14	39.20	105.63
August	43.75	78.65	41.02	79.87	44.00	78.88
September	43.10	79.35	41.33	78.49	43.80	74.90
October	40.38	83.56	38.46	81.72	40.50	76.63
November	43.13	104.00	41.63	97.85	44.00	98.99
December	48.25	98.00	44.95	92.64	47.75	98.00
Year	41.42	81.57	39.43	78.47	42.53	79.34

Joplin base and Platteville Zinc prices are on standard ores, 60 per cent. zinc. Second Joplin price is average for all zinc ores sold.

The year's production was 324,528 tons of all grades of zinc ores. The year's average price of $79.30 per ton was $32.66 per ton greater than the average price in 1914. With these comparisons it is indicated that a maximum production can not readily be increased, yet it is possible that the movement inaugurated by the high level of prices in 1915 may result in a larger increase in the 1916 yield, even though the price decline to a lower level. The production of this district is staple and can not be spasmodically influenced, advancing slowly and receding slowly with price variations.

Metallurgically, no effort developed toward larger mills. Instead of greater capacity for heads, the increase in yield was directed to the tails, by the addition from time to time of slime tables. The disposal of the tail waste is a problem being threshed out. The level surface of this section presents a situation unusual in mining regions. Some mines installed cars for waste delivery. This proved unsatisfactory. De-watering is now advocated, with a return to the belt-and-cup elevator, placing additional elevators on top of preceding dumps. Wet delivery is the easiest disposal of waste, but cost is against it in actual practice.

Montana.—The Butte district continued its rapid development, the Butte & Superior Co. being the leader in this, and during the past year enjoying the distinction of being the largest producer of zinc in the world, their output being 82,500 tons. The Clark interests have been developing their properties, and the Elm Orlu mine has been producing an average of 400 tons of ore per day, which has been handled at the Timber Butte mill. This mill has a capacity of 5000 tons of concentrate per month, but has been turning out only about 4000 tons on account of smelter facilities being limited. The output in zinc concentrates has run about 2000 tons per month. The Anaconda Copper Co. has been making rapid strides as a zinc producer, and has very ambitious plans for the future, including an electrolytic zinc refinery at Great Falls, with a capacity of 35,000 tons of zinc per year. Much attention has been given to flotation processes throughout this district, and the mill processes employed by the various mills nearly all make use of flotation methods, with a considerable increase in recovery.

Utah.—The production of zinc ore in the State was nearly double that of any previous year. One of the most striking features of the zinc mining was the development of the Promontory Point zinc deposits, a few miles west of Ogden. The estimated total of zinc produced in the State for 1915 is over 14,000 tons. The A. S. & R. Co. installed an electrolytic-zinc testing plant at Murray, which produced at the rate of 2 tons per day.

New Jersey.—The output of this State was very greatly increased owing to the heavy war demand for the spelter made by the New Jersey Zinc Co., who are the only zinc producers. Their mines at Franklin

Furnace, and adjoining mines at Sterling Hill greatly increased their output.

New Mexico.—The Salt Lake Mining Review summarizes the zinc mining of the State for 1915 as follows: Heavily increased shipments of zinc carbonate and sulphide ores and zinc sulphide concentrates were made from New Mexico in 1915. At Kelly, Socorro County, the principal producing mines were the Kelly, Graphic, and Juanita. The Ozark mill was operated continuously on the sulphide ores from the Graphic and the Kelly magnetic mill was completed. At Hanover, Grant County, zinc carbonate ores were shipped from the Hanover and other mines; and the building of a mill for the treatment of sulphide ores at Hanover was commenced. Both zinc carbonate and sulphide ores were shipped from the Cooks Peak district, and carbonate ores from the Florida and Tres Hermanas districts, Luna County. Zinc concentrates were shipped from the wet-concentration-electrostatic mill of the Pinos Altos M. & M. Co. The new magnetic separation mill at the Cleveland mine, at Pinos Altos, was completed and set in operation. A car of zinc ore was shipped from the Hermosa district, Sierra County. The production of zinc ore and concentrates from New Mexico was 39,970 tons of 36.3 per cent., as compared with 29,459 tons of 37.53 per cent. zinc in 1914.

New York (By D. H. Newland).—This State entered the list of zinc producers in 1915, through the operations of the Northern Ore Co. who completed their new milling plant at Edwards, St. Lawrence County, early in the year and thereafter made steady shipments of concentrates, at the rate of about 25 tons a day when running under full headway. The output went to Newcastle, Pa., for treatment. A feature of the mill—which is the second to have been built, the first having been destroyed by fire before it was placed in operation—is the use of a wet magnetic process for the separation of the blende and pyrite. This obviates the necessity of roasting the ore and gives a pyritous by-product that may be of commercial value when further treated. The mine developments so far have been encouraging, showing enough ore ahead to assure operations at the present rate for some time to come, without drawing upon other deposits of which the company has several under development in the vicinity of Edwards and south of there near Sylvia lake.

The Edwards zinc district is hardly comparable to any other in the country, although some deposits of similar character have been worked in a small way in eastern Canada. The wall rocks are crystalline limestones, among the oldest of the Adirondack formations, highly metamorphosed and heavily charged with silicate minerals like serpentine, tremolite, and talc. They are interfolded with dark hornblendic schists and intruded by granite which is perhaps the cause of their silication. The district is some 10 or 12 miles long, reaching from Edwards on the northeast to Sylvia lake in the town of Fowler on the southwest, but is narrow, seldom more than 2 miles wide. The well-known fibrous talc deposits occur in the same belt of limestones, in a parallel series, with similar strikes and dips. The zinc mineral is a dark iron-bearing blende, rather fine grained and compact, never displaying crystal outlines; specimens always show more or less pyrite in rounded grains, the proportion of the two minerals varying considerably from place to place, but the blende usually predominates. The other ingredients of the ore are galena, in amount less than 1 per cent. usually, and barite which constitutes a small percentage.

The deposits have the form of lenses and bands which follow the general structures of the limestone country. The bands have the general shape of veins, but there is no other similarity to open fissure fillings; rather they suggest replacements which have been controlled by the bedded structure of the limestones. They are not of large dimensions, the thickest part of the Edwards deposit now mined is from 12 to 15 ft. from wall to wall. At the ends they thin out to disappearance. Their contact with the walls is quite sharp as a rule, though in places offshoots from the main body may extend a little distance into the hanging or foot. As compensation for their small size they average high in metallic content as zinc ores run in these days, the usual mine product carrying around 20 per cent. zinc.

The Edwards mine is opened by an incline that follows one of the ore bands and that extends down over 400 ft. on an angle of 25 to 45°. The levels are spaced at intervals of 100 ft. Another shaft has been opened a few hundred feet away on a separate body which contains a good grade of ore but has not been worked. There are a number of prospects in the stretch from Edwards to Sylvia lake, but none as yet has been opened sufficiently to show its value. They are found on the McGill, Woodcock, Webb, Tamlin, Balmat, Streeter, Hubbell and Austin farms. The Balmat property belongs to the Northern Ore Co. and contains some good showings on the surface. The Dominion Co. of Gouverneur has done some prospecting on the Hubbell property where there is a chimney or shoot of blende and pyrite which have undergone more or less alteration, with the formation of red hematitie. The Lux Development Co. has prospected some immediately southwest of Edwards.

The district at best is a small one, though it has possibilities for further development and should prove a profitable field for mining with proper management. The natural conditions could hardly be better.

There is abundance of water, cheap electric power is available, and the district is nowhere very remote from the railroad. The population is devoted mainly to agriculture, but there are many who have had experience in talc mining.

Tennessee.—The zinc ores of the eastern Tennessee zinc belt were in great demand, owing to the high-grade spelter which is made from them, and the zinc-mining industry was greatly stimulated. The American Zinc Co. erected a new concentration plant during the year.

Virginia.—The lead-zinc ores of the State were given more attention than formerly, owing to the high prices. Considerable paint material was produced, and some zinc sold for spelter. Several companies are developing encouraging prospects, and the outlook for the coming year is good.

Wisconsin.[1]—War orders for spelter were reflected in the production and price of zinc ore. The net tonnage of zinc ore shipped to smelteries from the Wisconsin district, including Jo Davies County, Illinois, in the first 11 months of the year was 189,643,750 lb., an increase of 24 per cent. The tonnage of lead ore shipped was 6,338,640 lb., an increase of 31 per cent. while the shipment of sulphur ore, 26,534,310 lb., decreased 13 per cent. Aside from the high price of zinc ore, the feature of the year's progress was the increase in roasting capacity, as shown in Table 2. Low-grade ore was in little demand.

WISCONSIN ZINC OUTPUT, 1915
(First 11 months)

	Net to Smelteries.		Gross from Mines.	
	1914.	1915.	1914.	1915.
Highland	5,097,650	3,538,060	5,097,650	3,538,060
Linden	7,570,190	12,716,810	11,612,280	13,111,660
Miffin	6,855,120	9,202,560	40,743,320	49,619,750
Mineral Point	36,996,820	52,091,480	1,095,480	972,780
Dodgeville	1,254,290	1,109,150	1,516,270	1,109,150
Montfort	1,906,000	....	1,906,000	....
Platteville	12,781,940	18,735,760	5,287,560	15,098,470
Cuba City	19,640,100	31,605,060	5,370,430	3,642,600
Benton	31,740,910	36,759,190	69,563,720	119,173,940
Hazel Green	14,222,200	11,157,960	31,625,100	40,289,060
Shullsburg	2,096,070	1,130,300	19,209,800	5,712,300
Potosi	....	651,420	....	651,420
Galena	12,025,700	10,946,000	46,046,410	43,816,440
Total	152,186,990	189,643,750	239,073,920	296,735,630

Shipment of Field mines from Scales Mound is credited to Benton.

Wide variation was made in the price of zinc ore. The year opened at $50 per ton base for 60 per cent. grades. The price fluctuated between $55 and $75 until June, when $100 per ton was reached, and the price was maintained at $100 and over for 2 months, going as high as $130

[1] J. E. Kennedy, *Eng. Min. Jour.*

in the week ended June 19. The base declined as low as $60 during 1 week in August, but advanced as high as $110 in November. The highest premium price reported paid was $131.20. Prices paid for zinc ore taken under contract exceeded those paid in the open market, but were not available for publication.

A total of 57 mills and 12 roasters were in operation during the year. Fifteen concentrating mills were constructed: The Kittoe, Biddick, Lucky Six, Treganza, McMillan, Field-Thompson, Graham, Gilman, Long-henry, Cruson, M & H., Optimo No. 3, Stoner, K. C. & M. and Blackstone. The Wisconsin Zinc Co. will shortly erect four more: The Longhorn, Birkbeck, C. A. Thompson and East End Champion. The Frontier Co. will equip the Hird. The Wisconsin Zinc Co. built a Skinner-type roaster at the Champion mine, New Diggings. At the year end, the Mineral Point Zinc Co. was building a Skinner roaster at Mineral Point to replace the old cylinder type, and the Field Mining and Milling Co. was assembling a Mathey roaster at Galena. The most development work was done in the Benton-New Diggins territory, but many prospect drills were busy in every camp of the district.

The Wisconsin law enacted by the Legislature of 1913 assessing mineral lands for taxation upon the computed value of "ore in the ground," was amended in so far as it applied to lead and zinc deposits. By the terms of the new section the value of the land exclusive of its mineral content shall first be determined by the assessor, and to this shall be added, in lieu of the value of such mineral content, one-fifth of the gross amount of the sales of any ore extracted at any time and sold during the preceding calendar year. The sum total is the valuation subject to the current rate of taxation, separate and distinct from the personal property valuation of buildings, machinery, and equipment, which is likewise subject to the current rate of taxation.

Zinc Mining in Foreign Countries

Australia.—Special interest attaches to the Australian zinc production, since it has been due largely to the difficulty of getting these ores smelted which has caused the great shortage in spelter throughout the world. With the smelters of Germany and Belgium closed to this ore its disposal became a great problem, especially as it was contracted for in advance by German concerns, particularly Aaron Hirsch & Sohn, of Halberstadt, Germany. This company instigated legal proceedings to prevent the annullment or abrogations of its contracts. With uncertainty as to these contracts being void after the war, the question of what to do with the zinc output became a puzzling one. Most of the companies greatly curtailed their output, and arrangements were made in America and England for the smelting of a part of this ore, the remainder being stocked. During the 6 months ended in May 31, the Broken Hill Proprietary company raised 109,911 tons of ore at Broken Hill, as compared with 121,316 tons for the previous half-year. The Broken Hill South Co. raised 131,059 tons of sulphide ore for the half-year ended June 30,of an average value of 14.9 per cent. lead, 14.7 zinc.

The exportation of 50,000 tons of zinc concentrated by the Amalgamated Zinc Co., was approved by the attorney general, this having been sold in America, being shipped from Port Pirie, Australia to Galveston, through the Panama Canal.

The Broken Hill Proprietary has established a moderate-size smelting plant.

Belgium and France.—Previous to the war, Belgian production was about 200,000 tons of spelter, and that of France 64,000 tons. France imported about 19,000 tons, while Belgium exported about 140,000 tons. The *Mining Journal* gives the following information concerning the operators in this territory:

In France the following works are situated: Those of the Vieille Montagne at Vivivez, Bray, Dangu, Penchot, Levallois-Perret, and Autmont; that of the Cie. Asturienne at Auby (Nord); that of the Société de Malfidano at Noyelle-Godault (Pas de Calais); that of the Compagnie Metallurgique Franco-Belge at Mortagne (Nord); Mssers. Bloch's works at Saint Amand (Nord); and the Creil works in the Oise. These works treat blende or calmine ores from Australia, Tunis, Sardinia and Indo-China, and have an output of about 64,000 tons a year.

In Belgium are situated the chief works of the Vieille Montagne, comprising five separate establishments, known as the Angleur, Tilff, Valentin-Coq, Flone, and Baelen-Wezel. The most important of these is the Valentin-Coq, which covers about 250 acres. It comprises smelting plant and zinc white manufacture, and the production of specially pure brands of zinc, for which it possessed a large connection for armament work with the various European arsenals, for which purpose special ores only are used. These works turn out about 50,000 tons of metal per year, and are reported to be actively at work at the present time, though the metal is being stocked. Close to the German border there are the works of Moresnet, and in Germany four works—namely, those of Vorbeck, Oberhausen, Bensberg, and Wiesloch. The total output of the Vieille Montgne works in Belguim is about 104,000 tons of spelter. Another well-known company is the Compagnie Asturienne, which is a Belgian concern, with three works—in Spain, Aviles Santadder, and Kenteria—besides the one already mentioned in France.

This company has an output of 22,000 tons of spelter. Another company is the Austro-Belge, dealing in Sardinian, Italian, Tunisian, and Spanish ores. Their works at Corphalie-lez-Huy produced about 15,000 tons of spelter. Newer concerns are Prayon, with an output of 21,000 tons, and the Nouvelle Montagne, with an output of about 19,000 tons. The youngest of all is the Overpelt-Lommel, with an output, previous to the war, of about 14,000 tons.

Canada.—The estimated tonnage of zinc ores produced in Canada during 1915 is 15,553, containing 6300 tons of zinc. Several hundred tons came from Notre Dame des Anges, Quebec, but the greater part was from some 15 properties in British Columbia. For 1914 zinc shipments were reported as 10,893 tons, containing about 4500 tons of zinc.

The Consolidated Mining & Smelting Co. at Trail, B. C., after successful experimental development has installed at Trail a zinc-recovery plant, having an initial capacity of 35 tons of refined zinc, and has entered into a contract with the Shell Committee for a considerable tonnage of zinc to be delivered during 1916. A small quantity of zinc was recovered during the past year from the experimental operations. The Electric Zinc Co. has constructed a plant at Welland, Ont., for the recovery of refined zinc from zinc oxide. It is intended to eventually treat the ores from the Quebec district here.

At Silverton, B. C., a demonstrating plant, using the French process for the recovery of zinc, was operated during 1915 and satisfactory results are claimed.

In August the Dominion Government made an announcement with respect to a proposed bounty on zinc as follows:

"Bounties on a sliding scale not exceeding 2 cts. per lb. will be granted upon production in Canada from Canadian ores of zinc containing not more than 2 per cent. impurities, when the standard price of zinc in London, England, falls below £33 per ton of 2000 lb. provided that bounties shall not be payable on zinc produced before the expiration of the war or after the 31st day of July, 1917, or on zinc contracted for by the Shell Committee at a price of 8 cts. or over per lb. Total amount of bounty to be paid not to exceed $400,000."

Without protection of the kind given by the zinc bounty, Canadian producers were unwilling to go to the large expense of installing refineries. It will be observed that the object of the bounty is to ensure the producers against too great a fall in price in the period between the end of the war and July 1, 1917. The bounty will give an impetus to the refinement of zinc in Canada, and serve the purpose of ensuring a certain supply of brass to the Shell Committee.

The production of zinc is apportioned to various mines and districts by the *Canadian Mining Journal*, as follows: Zinc occurs in association with lead in the ores mined at the Bluebell, Cork-Province, and Utica mines, in Ainsworth division, but no account of these has been taken in making up the estimate, although it is known that some zinc ore was shipped from the Utica. Retallack & Co.'s mines at Whitewater are taken to have shipped ore that yielded 600,000 to 700,000 lb. Slocan mines from which zinc may be expected to be produced in larger quantity in 1916 than in 1915 are the Galena Farm (the concentrating mill at which was started late last year), Hewitt-Lorna Doone, Lucky Jim, Rambler-Cariboo, Ruth-Hope, Slocan Star, Standard, and Surprise with others in course of development that will probably add to the total production now that a custom concentrator is being operated in the neighborhood of Rosebery, Slocan lake. Approximate figures of production in 1915 from Slocan mines are—from the Standard mine 4,000,000 lb., the Surprise between 2,000,000 and 2,500,000 lb., and about 3,500,000 lb. as the total from the Galena Farm, Lucky Jim, Silverton Mines, Ltd. (Hewitt-Lorna Doone), Rambler-Cariboo, and Slocan Star. There is one fact that will tell in favor of 1916 to the disadvantage of 1915, namely, that there was last year much zinc product stored at Slocan mines awaiting sale that for this reason was not included in the production of the year, yet which is either now being shipped to the United States or will shortly be, and so will do to swell the total of production to be credited to 1916. One instance may be mentioned here; the zinc in concentrate stored at the Slocan Star mill has been variously estimated at from 10,000,000 lb. upward and late in the year this was sold, but; of course delivery will be in 1916; consequently this year will have the benefit of what was actually last year's production to the extent indicated.

Zinc carbonate ore was shipped from the H. B. mine, on Deer Creek, about 10 miles from Salmo, in Nelson mining division, in quantity sufficient to make it appear that a production of between 1,000,000 and 1,500,000 lb. of zinc was made there. Then shipments of zinc ore from the Monarch mine, in Northeast Kootenay are reported to have been in large enough quantity to suggest an output of more than half a million pounds of zinc. From these two sources, then, there seems to have been a total output of approximately 2,000,000 lb. of zinc. So far as known, there was not any commercial production of zinc elsewhere in the province.

China.—It is almost impossible to get any figures on the production of spelter in China, although considerable is produced in the provinces of Kweichow and Hunan, most of it coming from very small furnaces. According to an American consular report, a Hongkong firm recently placed an order in the United States for a considerable quantity of zinc. Large quantities are used in the field tributary to Hongkong, but heretofore these supplies have been secured almost entirely from Belgium and Germany.

Japan.—Within the last few years, Japan has made rapid progress in zinc refining, and it would seem now that Japan will be able soon to produce all the spelter needed for home consumption. During the past year some zinc was exported to Russia. Siberian ore which formerly went to Germany and Belgium has in some cases been contracted for by Japanese smelting interests. Refineries are operating at the Kamishima works, Okayama, and at the Miike mine, as well as at Yasojima, Niigata, Takachiho, Yamaguchi and Shikama, the ores coming partly from home mines, also from Siberia and Australia.

Germany.—The annual report of the Hohenlohewerke A.G. shows that during the fiscal year 1914–1915, the two zinc mines, Brzosowitz and Neue Helene, produced 283,512 metric tons of calamine-blende against 394,037 tons in the preceding year. The output of the zinc furnaces and rolling mills of the Breslau district was 23,825 tons of pig zinc, 2731 tons of zinc dust. The corporation erected several new furnaces for the production of refined zinc during the second half of the year. The zinc-plate rolling mills produced 7867 tons of sheet zinc, of which 7778 tons were sold. Owing to the unusual conditions brought about by the war statistics are unobtainable in most cases. However, there is evidently no shortage of spelter in Germany, prices being lower there than elsewhere. It is claimed that Germany had on hand at the beginning of the war a very large stock of the high-grade Franklin Furnace, N. J. ores, from which the zinc for war purposes is derived in considerable measure.

Great Britain.—The following extracts from an address made by the chairman of the Central Zinc Co. at the recent annual meeting of its stockholders is an excellent summing up of the zinc-smelting situation.

"For the first 4 months of our financial year—that is to say, for April, May, June and July of last year—our working was on normal lines on a six-distiller basis. On the outbreak of the war, our position at once became extremely difficult on account of the considerable number of reservists employed by us, who were immediately recalled to the colors, and also owing to the quick and patriotic response which many of our men who are not reservists made to the call for recruits. Of the trained hands in our distillery a good many were of German and Austrian natianality, and in view of the national importance of our continuing our output of spelter without interruption we decided, in consultation with the authorities, to retain those men under special condidions, by which they were virtually interned at out works, and so enabled us to assist in the production of a much-needed metal instead of being a charge on the country. By these means, except for about 5 weeks, when one of our furnaces was shut down for repairs, we were able to keep six distillers in operation until Nov. 16, when one had again to be shut down owing to acute general labor shortage, and we continued with five distillers until Dec. 16, when the bombardment of Hartlepool and Seaton Carew by the German cruisers took place. This outrage naturally roused the bitterest feelings of the inhabitants against all enemy aliens in the district, and in deference to these feelings we decided, in spite of the inevitable dislocation of out work which would follow, to apply for the removal and internment of these German and Austrian workers. The result of this was that from Dec. 19 until the close of our financial year, on Mar. 31, our operations were greatly restricted, and were with difficulty maintained even on a three-furnace basis.

"We lost no time and spared no effort in endeavoring to recruit Russian and Belgian labor to replace that which we had lost, and although for some time we were not very successful either in the quantity or in the quality of the men we got, we have, I am glad to say, since the financial year closed obtained a much more satisfactory supply of Belgian workmen, many of whom are trained distillery hands formerly employed in Belgian zinc works, with the result that we have now six distillers again in operation, and hope to start a seventh very soon, while an eighth is being completed as rapidly as possible and will, we hope, be available about the end of the year.

"I have often heard wonder expressed that, in spite of the fact that some of the most important sources of supply of zinc ores are situated within the British Empire, especially at Broken Hill, the industry of spelter making should be so much in German hands, and the Broken Hill mines so dependent on German buyers for the disposal of their material. We, at any rate, have done something to provide a British outlet and the Broken Hill Proprietary Co. has also established zinc works on a moderate scale in Australia; but the fact is that hitherto British spelter works have not been successful enough to attract large capital to the industry, owing mainly to the difficulty, both in this country and in Australia, of obtaining an adequate supply of skilled labor. We have ourselves experienced our full share of this difficulty, and have found that English workmen are most reluctant to undertake work of this kind to which they are unaccustomed and which, although it is not dangerous to health, is certainly laborious. In this respect England is at a disadvantage as compared with those continental countries in which spelter making has become almost an hereditary industry with certain classes of workmen, and which are also better situated in respect of the clays which are necessary for the retorts used in zinc distilling, but even on the continent, so far as I know, the average return on the large capital involved in zinc works is very moderate, and in some cases very heavy losses have been incurred.

"I am entirely in favor of England, if possible, making herself more independent of foreign countries in the manufacture of this metal, and the Government, I think, should assist by a duty on foreign spelter, or, failing that, a bounty on domestic spelter, but any attempt suddenly and hurriedly to build enormous new works here, such as I sometimes see advocated by those who know little of the difficulties would, I am sure, lead to dissapointing results, and whatever is done in the direction of increasing the domestic output of zinc will have to be done cautiously and gradually. It must be remembered that the spelter works on the continent, built at the cost of many millions, were at the outbreak of war quite sufficient to produce all the zinc that Europe in normal times can absorb, and if new works on a great scale are now to be built in England the result, unless some of the continental works should be destroyed before the war ends, may be an over-production of the metal and a fall in price, a state of affairs which, although it might be acceptable to galvanizers and brassfounders, would be calamitous both to the owners of spelter works and to the mines which produce zinc ores. Of such ores there is a great abundance in the world, and the limiting factor in the supply of metallic zinc does not lie in any scarcity of mineral deposits, but mainly in the high cost of works to convert these ores into metal and the difficulty of obtaining an adequate supply of skilled labor to make them successful. In our own case our policy is gradually to extend our works until they reach a capacity of 20,000 tons to 25,000 tons a year, which will mean an addition of from six to eight distilling furnaces to the seven we now have and the eighth which is in process of completion. We are also considering schemes for making refined zinc, of which there is considerable scarcity, and for establishing rolling mills for the manufacture of zinc sheets, but we realize that such extensions will require both time and money, and that perhaps they could be better undertaken by our parent company, the Sulphide Corporation, which has larger resources than we have, and which is directly interested in increasing by all possible means the outlet and market for its ores."

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Metallurgy of Zinc

By W. R. Ingalls[1]

Conditions in the zinc-smelting industry of the United States in 1915 rendered dollars so easy to get by anybody who had smelting capacity that the attention of smelters was devoted chiefly to the making of spelter in any old way, there being neither need for making improvements nor time to spare on them. In the Kansas-Oklahoma region there was a reversion to primitive methods, for the reason that they were the easiest in the inauguration of new smelting capacity, haste being a prime consideration. Many of the smelters who repaired old plants are using the auger machines of 20 years ago for the manufacture of their retorts and are making condensers by hand. This is being done even in some important plants, Such things, together with the reduced efficiency of labor, cut down greatly the zinc extraction to 80 per cent. and even lower. There is an immense breakage of retorts and condensers, especially in the smelting of Rocky Mountain ores, some of which contain as much as 20 per cent. iron. These plants will be run only so long as the price for spelter is high and the smelting margin is large. When the price and margin shrink, their owners expect to quit the business, and in the meanwhile do not intend to spend any money on plant that is not absolutely necessary.

In general the zinc smelters of the United States who gave any thought to the excellence of their practice confined themselves to the improvement of details. Thus one smelter reported better extraction of zinc from low-grade ore, not owing to the introduction of any novelty in practice, but simply to increased familiarity with the behavior of these low-grade ores and to the insistence of more careful work in the handling of the furnaces.

Another smelter reported the introduction of several mechanical improvements that resulted in greater economy in the handling of material. Other smelters experimented with mechanical gas producers. The Edgar Zinc Co. continued its experiments with coal-dust firing, but as yet has achieved no great success with this. The United States Smelting Co. inaugurated an experiment for the collection of zinc dust by the use of prolongs on the condensers, a reversion to old practice that was abandoned in Kansas many years ago, but may be economical under existing conditions.

The Kansas-Oklahoma region was favored with a better supply of natural gas in 1915 than for a long time previous. This was due to some small concerns selling out and to the increased pumping of gas that could not be put into the high-pressure lines for distant delivery.

In the Kansas-Oklahoma region, the most important improvement in blende-roasting is the lowering of the arch in the Zellweger furnaces, and in some instances the doubling of the furnace, the rabble being carried on the same shaft for the two furnaces. This, together with the lowering of the arch, saves fuel, the admission of unnecessary air being reduced. The original Zellweger furnaces were enormous wasters of fuel. With the recent improvements, they are still bad, but not so bad as they were.

At Argentine, Kan., the National Zinc Co. is building six Spirlet furnaces, which will be ready for operation early in 1916.

The Donora Smeltery

One of the important commercial features of 1915 was the expansion of the United States Steel Corporation—through its subsidiary, the American Steel & Wire Co.—in the zinc-smelting business. The new plans comprised the erection at Donora, Pa., of a plant designed for the smelting of 100,000 tons of zinc ore annually and the production of about 40,000 tons of spelter, the distilling equipment of the plant being about 9000 retorts. In speed of construction all previous records were broken in this plant. Earth was first turned over about the end of June, and spelter was first made on Oct. 20. However, the plant was not entirely completed until about Mar. 31, 1916. Even that will be only about 9 months from start to finish. Such a construction would ordinarily take 18 months. The Donora plant is unique in zinc-smelting construction, moreover, by reason of the extensive use of reinforced concrete in its several parts. About 50,000 cu. yd. of concrete was laid, whereof about 30,000 cu. yd. was reinforced concrete. The Donora plant comprises six Hegeler roasting furnaces and ten Hegeler distilling furnaces, each of 912 retorts.

Retort Discharging Machines

The United States Zinc Co. now has in operation at Sand Springs, Okla., six of the Simmonds discharging machines that were described a year ago. This means that the residues are being removed from six distillation furnaces with these machines, it having been found advisable to have one machine for each furnace in this type of smeltery. At Blende, Colo., there are two machines in operation, one taking care of one side of two furnaces. With a smeltery of this type, that is, with the furnaces end to end, one discharging machine can easily take care of one side of two furnaces. It is thought, moreover, that if a successful labor system can be devised, one discharging machine may be able to take care of one side of three or four furnaces.

At Blende the average time for removing the residues in the regular manner is 1 hr. 30 min. The machines do it in 20 to 23 min. At this plant the retort charge is often as much as 45 lb. per cu. ft., which is far in excess of the practice at other plants for a similar grade of ore.

Machines have been ordered to equip fully the Sand Springs plant, which consists of 14 furnaces, 400 retorts to the furnace. The Blende plant is to be fully equipped, after which an installation will be made at the plant of the Kusa Spelter Co., at Kusa, Okla.

The Grasselli Chemical Co., is also working on a retort discharging machine at Clarksburg, W. Va.

Zinc Refining by Re-distillation

The extraordinary premiums that have been paid for high-grade and superior intermediate spelter led naturally to the refining of common spelter by re-distillation. A large tonnage of refined spelter is now being produced in that way. There was no metallurgical novelty in this, a good deal of refined spelter having been so produced during many years by dross and junk smelters in this country and Great Britain, and also in Sweden and Norway, and perhaps elsewhere. The dross and junk smelters in this country commonly perform the re-distillation in large retorts. The smelters in the Scandinavian countries do it in electric furnaces. The practice recently developed in the United States is novel in that the ordinary ore furnace is used for the purpose. Yet even that is novel only in the making of a regular practice of it.

The same thing was tried about 17 years ago in one of the works of the old Cherokee-Lanyon Spelter Co., then managed by A. B. Cockerill. Mr. Cockerill, who was something of an experimenter, thought then to improve his metal product by re-distillation. He found that he could make a refined spelter assaying approximately 99.9 per cent. Zn, but he found also that he lost about 10 per cent. of his zinc in doing it (by absorption in retorts, breakage of retorts, failure to condense, etc.), and the premium realized for high-grade spelter at that time was not enough to pay for making it in this way. When, however, the premium rose to 10 @ 15 cts. per lb., as it did recently, the aspect of things was changed radically.

Nevertheless there is some doubt as to just how much profit there is in refining spelter by this method under existing conditions, exceptional as they are. The slabs of common spelter are broken up or are re-cast in little bars, and are piled up in the ordinary retorts, which are heated in the ordinary way. The direct cost of re-distillation is variously estimated at 0.5 to 1 ct. per lb., probably being nearer the lower figure than the higher. Then comes the cost of the zinc that is lost. This is variously stated at 10 to 12 per cent.—a confirmation of Mr. Cockerill's experience. If the common spelter that is being re-distilled costs 10 cts. per lb., the loss is 1 ct. per lb. If it costs 20 cts. per lb., it is twice as much. The third element of cost is the use of smelting capacity. In normal times, when there is a surplus, this might reasonably be reckoned as nil, but certainly not so at present, when smelting capacity is so urgently needed. An Iola furnace of 600 retorts is figured as taking about 30 tons of spelter per day for re-distillation, or 60,000 lb. Such a furnace takes normally about 12½ tons of calamine or roasted blende. If the latter, say about 15 tons of raw blende. Now if the smelter can make a profit of $40 per ton in smelting ore (he talks about such figures), he does not make it if he uses his furnace for refining spelter, and such use may therefore be reckoned temporarily as costing him $600 per furnace per day, or 1 ct. per lb. The total cost of refining is therefore from 3 to 4 cts. per lb., which is not bad if a premium of 10 cts. be realized. However, there has been some difficulty in bringing all of the product up to the highest grade.

Electrolytic Zinc Production

Without any doubt, the most important thing in the metallurgy of zinc in 1915 was the inauguration of electrolytic zinc production direct from ore on a large experimental, even a commercial, scale at several places, the most important of these being at Anaconda, Mont., where the production of electrolytic spelter at the rate of about 5 tons per day was begun. The results are considered so favorable that the Anaconda Co. has commenced the erection at Great Falls, Mont., of a plant capable of producing 35,000 tons of electrolytic spelter per annum.

The Anaconda spelter assays above 99.9 per cent. Zn. It is well known that the electrolytic spelter produced for many years at Winnington, England, is guaranteed 99.95 per cent. Zn. I have often expressed the opinion that there was no great promise in a hydrometallurgical-electrometallurgical process of zinc extraction unless use could be made of the anode reaction (as at Winnington) or some specially favorable conditions otherwise might be found to exist. That appears to be the case with the Butte ore. In roasting there is relatively little formation of zinc ferrite, and consequently zinc extraction is high. Moreover, the ore is rich in silver, whereof 90 per cent. or so ought to be recovered by this process against only 65 to 70 per cent. by the pyrometallurgical process. Both of these are strong points. Of course, with existing commercial conditions, electrolytic zinc may be produced profitably out of many ores. However, the Anaconda metallurgists are of the opinion that they can carry on the process successfully under normal conditions.

Chemistry of the Process

The chemistry of the process used at Anaconda is described in U. S. Patent No. 1167700, granted to Frederick Laist and Frederick F. Frick, Jan. 11, 1916. According to this the proper performance of the cycle depends upon the presence of manganese. Its function is to serve as a carrier of oxygen for the oxidation of ferrous to ferric iron, thus rendering possible a complete separation of iron and affording a purified solution from which zinc may be recovered by electrolysis. In the course of this electrolysis the manganese is restored to a state of oxidation higher than the manganous state, and thereby becomes available for re-use in the process.

The calcined ore is treated at a temperature of 50 to 65° C. with sufficient dilute sulphuric acid so that there is 5 to 10 per cent. excess acid over that required to complete the reactions, by which the metals in the calcined ore are dissolved. A portion of the iron enters into solution as a ferrous salt, in which state it is not completely removed by the usual basic precipitants (lime zinc, oxide, etc.). It is necessary, therefore, to oxidize this ferrous iron, and in the cyclic operation of the process this is accomplished through the agency of the manganese, which enters the cycle at this point in one of its higher states of oxidation—as for instance, in the form of manganese dioxide. The oxidation of the ferrous sulphate takes place according to the equation,

$$2FeSO_4 + MnO_2 + 2H_2SO_4 = Fe_2(SO_4)_3 + MnSO_4 + 2H_2O$$

Having accomplished the leaching and having a slight excess of acid solution, sufficient milk of lime or zinc oxide is added to render the solution neutral or slightly basic. The iron and most of the other impurities except copper are precipitated, and the precipitated impurities are so coagulated that filtration is very rapid.

The solution, purified from elements harmful to electrolysis, is subjected to electrolysis using insoluble anodes—as lead, for example—and suitable deposition blanks or zinc starting sheets for cathodes. The electrolytic reactions are:

$$ZnSO_4 + \text{current} = Zn + SO_4$$
$$SO_4 = SO_3 + O$$
$$SO_3 + H_2O = H_2SO_4$$

The oxygen liberated from the SO_4 at the anode effects the oxidation of the manganese; thus,

$$2MnSO_4 + 2O + 6H_2O = 2HMnO_4 + 2H_2SO_4$$
$$2HMnO_4 + 3MnSO_4 + 2H_2O = 5MnO_2 + 3H_2SO_4$$

It is apparent from the foregoing that a regenerated sulphuric-acid solution containing manganese in higher stages of oxidation than the manganous state results and is directly available for leaching additional portions of roasted ore, where the higher oxides of manganese are available for oxidation of ferrous iron and are themselves reduced to manganous sulphate, thus making a cyclic process in which the desirable manganese may be used over and over again and in which the original supply or any deficiency may be supplied to the raw zinc ore or concentrates in the form of carbonate or sulphide ores of manganese.

Details of the Process

In the performance of the process the ore is roasted in Wedge furnaces at a temperature of 900° C., which, with a fuel consumption of 5 to 6 per cent. delivers a product containing only about 0.3 per cent. S as sulphide. The roasted ore is leached in a Pachuca tank with air agitation, the lixiviant being spent solution from the electrolytic cells. The percentage of zinc dissolved is from 85 to 95. After addition of limestone to neutralize free acid, the pulp is run to a battery of Minerals Separation flotation agitators, where it is agitated and aërated to precipitate ferric hydrate. The charge thence passes to a Dorr thickener, which delivers clear overflow to solution storage tank and mud to Oliver filter. The latter gives cakes of gangue containing iron, lead, silver, etc., which go to blast furnaces, and solution which is united with that overflowing from the Dorr thickener.

From the solution tank the liquor is drawn into a tube mill filled with zinc balls, which precipitate copper and cadmium, flowing thence to a circular filtering tank having a quartz bottom, and finally to a Shriver plate and frame filter press, which completes the clarification. The purified solution goes to a cascade of 21 electrolytic cells, whereof there are two series, and upon entering, is mixed with one-half of the spent electrolyte from the tail cells, which brings the cell feed up to 2½ per cent. free H_2SO_4 and 5 per cent. Zn.

In flowing through the cells the temperature of the electrolyte is kept below 70° C. by means of lead coils conducting cooling water, which is done in small boxes interposed between the cells. The anodes are of pure lead, the cathodes of aluminium. Solution is electrolyzed at a current density of 23 amp. per sq. ft., the voltage drop being 3.8 to 3.4 volts per cell, decreasing as the acid increases. Current efficiency is 93 to 94 per cent. The cathode is finished within 48 hr., by which time it has attained a weight of 50 lb. and is then peeled from the aluminium sheet.

Other Processes

Apart from the Anaconda work the most ambitious plans carried on in 1915 were those of the Consolidated Mining and Smelting Co. of Canada, which continued the experimental work begun several years ago. In the last official report of this company it is stated that spelter of good grade has been produced at the rate of 1000 lb. per day from ore from the Sullivan mine, and that the results were sufficiently promising to warrant the building of a plant capable of producing 25 to 35 tons of spelter daily. Construction of this plant is well advanced, and it is expected to be in operation early in 1916.

Electrolytic zinc was also produced in 1915 on an experimental scale by the Electro Zinc Co. at Welland, Ont., while some work in this line was done at Keokuk, Iowa, at Garfield, Utah, and at Bully Hill, Cal., and there were one or two other operations (one of these employing the Isherwood process) that may not yet be mentioned publicly. The work at Welland is unique in that the dissolving of the zinc and the electrolysis of the solution are performed in the same vat, the cathodes being inclosed in canvas bags. All of the other work, so far as I know, is being done on lines similar to those at Anaconda.

Before going any further, let it be well fixed in the mind that the conditions that have existed in the zinc industry during the last year are not only unprecedented, but also it is certain that they cannot be otherwise than ephemeral. They have been due to a shortage of metallurgical capacity, not of ore in the least degree, and that shortage is being reduced with extraordinary rapidity. In the meanwhile, however, there has naturally been a huge metallurgical margin—even \$60 per ton of ore against a normal of about \$15—in the manufacture of common spelter, and with such a margin it has been good sense not only to commit metallurgical crimes, but also to institute new processes that would not ordinarily be profitable. In the manufacture of high-grade spelter the margin has been much higher, so much so that the possibility of it would 2 years ago have been considered nothing less than preposterous.

Now, the electrometallurgy of zinc is no new thing. The electrolytic refining of impure spelter was tried on a large scale by Nahnsen in Upper Silesia in the '90s, the hydrometallurgical-electrometallurgical treatment of zinc ore was essayed disastrously by Ashcroft at Cockle Creek, N. S. W., in a works costing about one million dollars. Doctor Hoepfner developed a process that was put into use at Führfort on the Rhine and at the works of Brunner, Mond & Co., at Winnington, in England. At the former it was abandoned after a short time; at the latter it has been continued through a long series of years, making a few hundred tons of spelter annually, and is in use at the present time. The electrometallurgy of zinc has therefore a commercial history of respectable antiquity.

Difficulties in the Art

In the early days of the art, both commercial and experimental, difficulty was experienced in obtaining dense deposits on the cathodes, spongy zinc being a stumbling block, but while this matter required some study for its mastery, it was manifest that the real difficulties of this process were the getting of zinc into solution rather than out of it and the large amount of power required for zinc precipitation.

With regard to the former point, I refer to the formation of insoluble ferrite of zinc in roasting, with the consequence of relatively low extraction of zinc. That is experienced in the case of many, perhaps most, ores that it is desired to treat. To illustrate, roasted Joplin blende may be leached with sulphuric acid so as to cause it to give up 97 or 98 per cent. of its zinc, the residue being a white silica sand, but nobody wants to treat Joplin ore by a hydrometallurgical process, for the reason that it would be less economical than ordinary smelting. On the other hand, certain mixed ores high in iron, like those of Leadville, Colo., may give up only about 65 per cent. of their zinc. So low an extraction would in itself be prohibitive in most circumstances in ordinary times. It is possible that the roasting might be conducted in such a way as to steer clear between the Scylla of zinc ferrite on the one hand and the Charybdis of undecomposed zinc sulphide on the other hand, but that question has not been investigated with definite results, so far as I know. With regard to the high power required for the electrolysis of zinc solutions with insoluble anodes, the expense of it, when imposed upon the cost of roasting, leaching, re-melting cathodes, re-working between-products, etc., is likely to make the cost of hydrometallurgical-electrometallurgical zinc extraction too high to be ordinarily considered.

I have, therefore, repeatedly expressed the opinion that metallurgical processes of this sort were unlikely to be successful commercially, unless: (1) Exceptionally cheap hydro-electric power, such as the $6 or $7 per annual hp. of Norway and Sweden, were available; or (2) unless use could be made of the anode reaction, such as the liberation of chlorine by the electrolysis of a chloride solution and the employment of it for some chemical manufacture, as at Winnington, England; or (3) unless certain especially favorable conditions otherwise existed. By the last I mean such things as high grade of the run-of-mine ore, a kind of ore that will give up a high percentage of zinc by lixiviation with sulphuric acid, and ore high in silver and possibly lead. These points are almost determinative. In the pyrometallurgy of zinc the extraction of silver is, perhaps, about 65 per cent. In the hydrometallurgy of zinc it ought to be upward of 90 per cent., perhaps as high as 95 per cent. The situation with respect to lead is somewhat similar. It is needless to dwell upon the importance of this in the cases of ore exceptionally high in silver.

Favorable Conditions at Butte

Now, in the treatment of the Butte ore at Anaconda about all of the favorable conditions that I have enumerated under the third head exist. The ore raised from the mine is of rather high grade, it is of a character that enables 90 per cent. of the zinc, or more, to be extracted by sulphuric-acid lixiviation, and as zinc ores go, it is exceptionally high in silver (the concentrated ore going 20 oz. silver per ton or thereabouts). Moreover, the Anaconda Co. is introducing zinc extraction in connection with its other great metallurgical work, thus dividing general and administrative expenses, etc. It is able to obtain moderately cheap power at Great Falls, and finally, what is not least in importance, it possesses about the best metallurgical organization of any concern in the United States and is instituting this new process at a time when there ought to be commercial profit in spite of any imaginable infantile disorders. I am not free to communicate such figures respecting the Anaconda results as I know, but I may say that the Anaconda management is thoroughly aware of the exceptional conditions existing in the zinc industry at present, and is nevertheless of the opinion that with its peculiarly favorable circumstances it can continue the production of electrolytic zinc in competition with everybody else in normal times, or even in the hard times that may be experienced after the termination of the war. The promise of the development of the hydrometallurgy-electrometallurgy of zinc as a commercial art on a large scale has therefore already become a prospect. There is to be such an art. The magnitude that it will attain and its effect upon the zinc industry of the world remain for the future to tell, but that it is going to have an early and important influence is not to be doubted.

Turning attention to some of the technical features of electrolytic zinc production, the conditions governing the electrolysis of zinc solutions were exhaustively treated by Dr. Victor Engelhardt in a paper read at the first general meeting of the Gesellschaft Deutscher Metalhütten- und Bergleute and published in *Metallurgie* a few years ago. A summary of Doctor Engelhardt's conclusions, together with some additional notes, was published by Prof. J. W. Richards in *Transactions of the American Electrochemical Society,* 25, pp. 281–290. The ideas of Doctor Engelhardt, who is the chief engineer of the electrochemical division of the Siemens & Halske Co., of Berlin, are exemplified in what are called the Siemens & Halske and Isherwood processes. However, in the late development of zinc electrolysis, "processes" and patents have played but slight part. With recent experimenters the matter of spongy-zinc deposits appears to have been among the least of the difficulties. Mr. Keating succeeded several years ago in depositing smooth, solid zinc on his cathodes at Bully Hill, Cal., while as for Mr. Laist, he accomplished this part of the process as a matter of course, just as simply as if he were depositing copper, the necessary precautions as to purity of solution, etc., being naturally taken.

Grade of Electrolytic Zinc

With regard to the grade of electrolytic zinc, high purity is easily obtained. This is something that is far more under control than in refining by fractional distillation. Lead ought not to go appreciably into solution at all, while iron, copper and cadmium—the other common impurities of spelter—are readily precipitated from the solution. The spelter first made at Anaconda was higher in cadmium than is permitted by the standard specifications for "high-grade." At that time zinc dust, more or less impure, was being used as the precipitant for cadmium. Running the clarified solution through a tube mill filled with zinc balls corrected this, and the grade of the spelter was then raised to upward of 99.9 per cent. Brunner, Mond & Co. have been for many years guaranteeing their electrolytic spelter at 99.95 per cent. Zn, and there is no reason why the Anaconda spelter should not be made as good as that.

Is electrolytic zinc extraction going to revolutionize the metallurgy of zinc? Unqualifiedly, no. When the zinc industry returns to its normal status, conditions will be in the main as they were before the war and the principles that I have previously stated will continue to obtain, with the difference that some people will have learned the details of the art, will have gone through the period of infantile mistakes in a time when almost any mistake was of no great consequence. By that time some of the concerns possessing exceptionally favorable conditions—Anaconda, if anybody—may be able to continue. Others will not.

However, there are certain new industrial features that cannot yet be clearly estimated and may have a modifying effect upon this forecast. One of these relates to the matter of high-grade zinc. Previous to the war that class of spelter was produced in limited quantity and sold at a premium over common spelter of about 2½ cts. per lb. Inventors, promoters and others who talked about making such zinc were discouraged from reckoning upon the premium by the dictum that the market would not take any more than the then supply, which was indeed artificially limited, and that it was unsafe to count on anything but the price for common spelter. During the war high-grade spelter has fetched 40 cts. per lb., and at times the demand for it has been insatiable. This demand has been especially in connection with the manufacture of ammunition and may be expected to cease with the war, but will the advertising that high-grade spelter has had and the wider knowledge of its peculiar properties that has been acquired give it a more extensive use in the peaceful arts and a maintenance of the premium for it, that will be to the advantage of the electrolytic producer? Or will it become a drug in the market, with entire disappearance of price differential? These are questions that nobody yet knows enough to answer reasonably.

The Bearing of Flotation on the Metallurgy of Zinc

Another new and uncertain factor is the bearing of the flotation process of ore concentration upon the metallurgy of zinc. I think that this had a good deal to do with the institution of the Anaconda work. About all metallurgical work is a sequence of steps of concentration and refining, treating the bulk of the ore by a cheap but wasteful process and delivering a concentrated product to a more costly but less wasteful process. Now, most experimenters in the hydrometallurgy and electrometallurgy of zinc heretofore have contemplated the application of a costly process to the run-of-mine ore. The flotation process has enabled ore to be concentrated at relatively small cost with but slight loss. Let it be observed, therefore, that Mr. Laist is applying his costly process not to run-of-mine ore, but to a flotation concentrate in which about 90 per cent. of the zinc is concentrated in about one-fourth of the original weight. This is the new and important feature of recent zinc electrolytic work.

We must let our thoughts run a little farther ahead. The treatment of flotation concentrate is one of the present troubles of the zinc smelter, owing to its excessive fineness, which produces difficulties that it would take me too long to describe. Yet the proportion of this class of ore that the zinc smelter is getting is still relatively small. The supply of it is, however, bound to increase, and when it becomes large, the troubles of the zinc smelter will really begin. Now the hydrometallurgist will have the same troubles up to and through the roasting of the ore, but he will be free from those that arise in the distillery. In so far he will have an advantage over his brother pyrometallurgist, but whether it will be a weighty advantage I do not venture to offer an opinion.

Another thing that may help the hydrometallurgist is improvement in the method of roasting. Twenty-five years ago he used to talk about sulphate roasting. He did not in practice find that idea to work out as well as he expected. While he might be able to render 40 or 50 per cent. of the zinc soluble in water, he found there was too much undecomposed sulphide left behind after leaching with sulphuric acid. So then he said he would roast the ore completely, leach all the zinc with sulphuric acid and be done with it. To his surprise he found that much of the zinc had been rendered insoluble by the formation of zinc ferrite, if iron were present in the ore, as was almost always the case. The roasting of ferruginous blende in such a way as to convert all the zinc into sulphate and oxide, avoiding both sulphite and ferrite, which may perhaps be done by correct control of temperature, perhaps by some other control, is an interesting subject for investigation. Mr. Laist has given some attention to this by carefully limiting the temperature of his roasting furnace. However, I think that perhaps the danger of ferrite formation is not very great in the case of his ore. Anyway, I know that the danger is not very great in roasting some similar ore of Butte, without much regard to the matter of temperature.

PROGRESS IN ORE DRESSING AND COAL WASHING IN 1915

By Robert H. Richards and Charles E. Locke

General

Progress in ore dressing during the past year has been mainly progress in flotation, with the accompanying changes that the introduction of flotation has made in milling operations. Primarily, flotation has had the effect of solving the slime problem. With slimes no longer a bugbear, the production of slime is not avoided to such an extent, flow-sheets have been simplified, crushing is carried finer, and in some cases all tailings are crushed fine enough for flotation, less concentrates are saved in the coarser sizes, that is, the ore is crushed finer before concentration begins, fewer steps are made in crushing, less middlings are made to be re-crushed, and the total extraction of the mill is increased. Although more power is required for the finer crushing and for the agitation, especially where mechanical agitation for frothing is used, still the added extraction more than offsets this and leads to a greater profit per ton treated. The final result is, that lower grade ore can be treated which was formerly unprofitable, and old dumps and tailings can be worked over at a profit. Many problems still remain to be worked out in connection with flotation, but judging from the advances during the past year, these problems are going to be solved one by one as time goes on. The flotation process acts as a guard against losses in slimes and muddy water leaving the mill, so that the main loss with which the mill man is now concerned is that which occurs in the form of included grains, that is, mineral not freed in crushing.

Crushing and Grinding

Rock-breakers.—The use of large jaw-breakers is on the increase. The latest is a breaker with mouth opening 66 by 86 in.[1] These large jaw-breakers are preferred to gyratory-breakers of the same capacity because the larger mouth opening saves hand-sledging.

On the Rand, in South Africa, the gyratory-breaker is preferred by the Rand mines and Consolidated Goldfields groups, while the jaw-breaker is preferred by some of the other companies.[2] The gyratory is

[1] *Min. Sci. Press,* **110,** 201 (1915); *Mex. Min. Jour.,* **19,** 127 (1915); *Eng. Min. Jour.,* **99,** 577, 865 (1915).

[2] F. L. Bosqui, *Bull. Amer. Inst. Min. Eng.,* **101,** May, 1915, p. 997; **108,** Dec., 1915, p. 2436.

considered to be more efficient and cheaper to operate where tonnages are large, and also is well adapted to the finer breaking. The jaw-breaker is simpler, has relatively less weight, requires less vertical height, and is preferred for coarse preliminary breaking where fines are objectionable.

The Symons disc-crusher is used and finds favor in many mills where the ore is hard and brittle, but some mills have found it unsatisfactory. The reason is that it is not adapted to wet sticky ores, and the undersize must be eliminated from the feed. The field for this machine is in taking feed up to 4 or 6 in. and crushing it down to about 1 in.

Details of rock-house practice at Lake Superior have been given by L. H. Goodwin.[1] Jaw-breakers are practically universal. These crush the mine rock, usually in one reduction to 4-in. size for feed to steam stamps. Formerly, two or more breakers were used in series, but best modern practice is to reduce the number and increase the size up to 24 by 36 in., or even up to 24 by 48 in. at the Calumet and Hecla. The Calumet and Hecla breakers are made of one solid ribbed casting with longitudinal reinforcing bolts. Jaw plates are usually of manganese steel, although the Calumet and Hecla uses chilled iron in crushing soft amygdaloid. Corrugations vary from a width of 12 in. at the Quincy to 2 in. at the Copper Range, and even to smooth at the Calumet and Hecla. The tendency is toward smooth jaws as being better suited for mass copper. Speed is, in general, proportional to hardness of rock. The Quincy, on soft amygdaloid, uses 140 r.p.m., the Calumet and Hecla, on conglomerate, which is harder, uses 175 r.p.m., and the Copper Range, on dense amygdaloid, uses 185 r.p.m. The development of increased angle of nip is noteworthy. Former practice with breakers in series, was to reduce from 24 in. at mouth to 14 in. at throat in a vertical height of 4 ft. A reduction from 24 in. to 4 in. is now made in the same distance, and even in a decreased distance of only 3½ ft.

A plea for a more rational design of jaw-breakers has been made by M. W. Heller.[2] In view of the fact that a breaker running empty takes 70 per cent. as much power as when crushing, he believes smaller breakers should be used. He argues that the manufacturers are not taking proper consideration of the jaw angle and its relation to the degree of reduction.

Additional instances of the use of underground crushing are noted. The Creighton mine at Sudbury, Ont., and the Dome mine at Porcupine have both put breakers underground.[3]

Weight, life and cost of wearing parts of gyratory-breaker at Belmont mill, are reported by A. H. Jones.[4]

[1] *Eng. Min. Jour.*, **99**, 1061, 1107 (1915); **100**, 7, 53 (1915).
[2] *Eng. Min. Jour.*, **99**, 399 (1915); *Jour. Chem., Met. Min. Soc. So. Afr.*, **16**, 11 (1915).
[3] A. E. Hall, *Eng. Min. Jour.*, **99**, 192 (1915)
[4] *Bull. Amer. Inst. Min. Eng.*, **104**, Aug., 1915, p. 1731.

At the International Engineering Congress, G. O. Bradley[1] outlined the design of a coarse crushing plant, using breakers and rolls for the daily reduction of 1000 tons of average ore to ¼-in. size. One special feature of his design is the use of automatic balanced skips in the place of bucket elevators.

Rolls.—To prevent corrugations on rolls from slipping off large hard lumps, the Utah Apex mill has four longitudinal slots in the face of the rolls. These slots cause such lumps to be nipped by the time a roll has made a quarter revolution. Other mills avoid corrugations by constant use ofcarborun dum bricks, which are kept most of the time at the ends of the rolls to prevent formation of flanges. The Utah Copper Co. has found it a distinct advantage to install solid heavy flywheels on their rolls in place of lighter spoked wheels.

Gravity stamps continue to drop in spite of the advent of substitutes.

Built-up posts of 1-in. plank, instead of the common one-piece posts are used in the La Lucha cyanide mill. There seems to be no reason why this practice should not be extended.

California stamp-milling practice tends to continue along conservative lines, although there are two all-sliming cyanide plants using stamps and tube mills, the Globe Consolidated at Dedrick, and the Black Oak at Soulsbyville. Amalgamation and two-stage reduction is practised in the Plymouth Consolidated mill.[2]

The Amador Consolidated mill has been remodelled as an amalgamating and cyanide mill somewhat after the South African practice.[3] Trommels with ⅜-in. holes precede the stamps and remove 25 per cent. of the ore as undersize which by-passes the stamps. The stamp screens are ⅜ to ¾ in. No inside amalgamation is practised. The 20 stamps are followed by two 8-ft. by 36-in. Hardinge mills which grind to about 30-mesh. The re-arranged mill will treat 300 tons per day against 90 tons formerly by stamps alone with 20-mesh screens. One 4½-ft. by 72-in. Hardinge mill is used for re-grinding concentrates to 200-mesh. It is planned to discard stamps for ball mills or some other crushing device.

The question of California milling practice has been discussed by E. S. Pettis.[4]

A more general article showing diagrammatically many combinations in actual use, of amalgamation in connection with stamps, tube mills and classifiers, has been written by A. Del Mar.[5]

The Homestake milling practice has been well described in past years. A. J. Clark[6] has supplied some details of the stamp work with

[1] *Min. Sci. Press,* **111,** 592 (1915); *Met. Chem. Eng.,* **13,** 721 (1915).
[2] Mineral Industry, **23,** 806. L. A. Palmer. *Met. Chem. Eng.,* **13,** 617 (1915).
[3] T. S. O'Brien, *Eng. Min. Jour.,* **100,** 255 (1915).
[4] *Min. Sci. Press,* **111,** 433 (1915).
[5] *Min. Sci. Press,* **111,** 130 (1915).
[6] *Bull. Amer. Inst. Min. Eng.,* **103,** July, 1915, p. 1381; **108,** Dec., 1915, p. 2453.

costs, also of the tube mills in the re-grinding plant. Electric drives for stamps, now in operation for over 2 years, permit more continuous operation. Open-front mortars show a decided advantage. Wood chips are recovered from the mortar and burned, and the ash assays $300 per ton. It is probable that if re-building, the present 900-lb. stamps would be replaced by heavier stamps, although the only apparent advantage of heavy stamps is that of compactness.

The stamp milling practice at the Tonopah plant of the Belmont Milling Co. is illustrative of modern Nevada practice.[1] The outline of the operation is to sort out waste rock on steel picking belt, crush to 1 in. in gyratory-breakers, stamp through 4- and 6-mesh, grind in eight tube mills so that 75 per cent. passes 200-mesh, concentrate on Wilfley tables and cyanide the tailings. The mill crushes 500 tons in 24 hr. using 60 stamps and eight 5 by 18-ft. tube mills.

The stamps weigh 1250 lb. each. Mortars are of narrow type. Forged-steel dies and chrome-steel shoes are used. A 5-ton crane travels on a track above the battery posts and serves for speedy removal of a broken camshaft. Two camshafts, right and left, are kept assembled on the camshaft floor for an emergency. Thermit welding of broken camshafts has been tried, but without great success. The cost of welding a shaft was $42.53. Details of cost of erection and operation are reported.

A very comprehensive discussion of the history and present practice of milling in South Africa has been given by F. L. Bosqui.[2] The weight of stamps in recent mills varies between 1550 and 2000 lb. Concrete mortar blocks are used, but cast-iron anvil blocks have been abandoned in most of the more recent mills as tending to cause greater breakage of stems and camshafts. Stamp duties run as high as 20 tons per day per 2000-lb. stamp with 3-mesh and 2-mesh screens, and even to 29 tons with 2000-lb. Nissen stamp and 3-mesh screen, although most of the mills have lighter stamps and finer screens and range between 6 and 15 tons per stamp. The Nissen single-unit stamp is represented by only 16 stamps in the district, although it has definitely shown its superior capacity over stamps arranged in five-stamp units. It undoubtedly does not produce such a large percentage of fines and thus throws more load on the tube mill.

In the opinion of W. B. Urquhart,[3] stamp mill dies may be made to wear more uniformly and without cupping, by the use of individual water jets directed diagonally on top of each die, each jet being controlled by a separate valve.

Tube Mills and Ball Mills. Fine Grinding.—One finds it hard to

[1] A. H. Jones, *Bull. Amer. Inst. Min. Eng.*, **104**, Aug., 1915, p. 1731.
[2] *Bull. Amer. Inst. Min. Eng.*, **101**, May, 1915, p. 997; **108**, Dec., 1915, p. 2436.
[3] *Mex. Min. Jour.*, **20**, 251 (1915).

realize that not over 5 years ago millmen were in doubt regarding the propriety of using tube mills in ore-dressing operations, owing to the belief that they would produce too much slime. Nevertheless, the tube mill has steadily found its way into concentrating mills and is recognized today as the most satisfactory grinder for table and vanner work, and has no rival for flotation work. Now the same principle of crushing action is finding application in a coarser field by the use of the so-called ball mills. The term ball mill formerly meant short cylinders charged with steel balls and having a screen around the entire circumference. Now the term includes large short cylinders with steel linings, without screens, charged with steel balls, receiving feed at one end and discharging at the other. In fact they may be said to be large short tube mills using steel balls instead of pebbles. The large diameter, together with the increased crushing power of a steel ball, due to its greater weight as compared to a flint pebble, enable these mills to receive material direct from a breaker at 1½ in. or larger, and reduce it in one operation to a product suitable for table feed. Unless coarse mineral is to be saved, the crushing operation becomes very simple, consisting of breaker, ball mill and tube mill, in three successive steps. It is predicted that these ball mills will replace stamps and Chile mills, as being more efficient, more compact and less noisy.

The Marcy mill[1] is the best known of the new type of ball mills. Large installations of them have been made by the Inspiration Co., the Utah Copper Co. and others. It is reported that the American Zinc Co. is installing them in Tennessee. In the Inspiration mill there are two Marcy mills per section, each mill grinding 400 tons of breaker feed per 24 hr., so that it will practically all pass 48-mesh. The two tube mills are connected up with two Dorr classifiers in a very novel and compact manner, the product of one mill going to a classifier which delivers coarse material to the other mill and *vice versa*. Considerable trouble was had at the start, due to breaking of the large steel castings which form the ends of the mills. This difficulty is purely mechanical and should be readily overcome. The steel lining is arranged in overlapping sections forming steps, so that the balls cascade from one step to the next, much like the old style ball mill.

At the Utah Copper Co.'s mills, the Marcy mills have replaced the fine rolls and Chile mills. Each mill is 8 ft. diam., 6 ft. long, has carbon-steel liners and ⅛-in. slot grate, is charged with 2½ and 5-in. chrome steel balls and makes 20 r.p.m. Each mill is designed to treat between 400 and 500 tons in 24 hr. The feed is 2 in. and finer and 85 per cent. is coarser than 48-mesh. The product is uniform in size, probably all below

[1] Mineral Industry, **23**, 814.

20-mesh and about 45 per cent. will pass 48-mesh. The water to solid ratio in the mill discharge is 1:3. The wear of balls is reported to be 0.03 lb. per ton and of liners 0.13 lb. per ton. The power required is 7 kw.-hr. per ton ground. Steel shells are preferred, as cast iron has a tendency to crack. In another installation an 8-ft. mill is reported to have crushed 4-in. maximum feed to 48-mesh, with a steel consumption of 0.75 lb. per ton, and power consumption of 12 hp.-hr. per ton.

At the Alaska Juneau mill a ball mill 8 ft. diam. 6 ft. long, occupies a space of only 14 sq. ft. The crushing of 400 tons per day, from breaker size to 40-mesh, is accomplished by two of these mills in series.

It seems probable that if the erection of the Alaska Gastineau mill had been delayed for a year or two, it would have been equipped with ball mills instead of rolls for crushing to 10-mesh.

The change to ball mills and tube mills will, of course, be gradual, and the sentiment will not be universal, even in gold mills, in favor of the change. The Portland mill at Cripple Creek, has found Chile mills very satisfactory, and naturally will not be inclined to make a change. The special milling problem in the Golden Cycle mill at Colorado Springs, is admirably solved by dry ball mills of the screen type crushing to 14-mesh, and wet Chile mills crushing to 30-mesh. For cleaning the clogged Chile mill screens at this mill, a sand blast is used very satisfactorily.

South African mills use the stamp-tube mill combination. According to Bosqui,[1] who describes the various modifications of practice there, including the arrangements of tube mills, plates and classifiers, the general opinion is that 3-mesh stamp mill screen is about the economic limit of size for tube-mill feed, although a maximum of 1 in. is sometimes used. Selected pieces of banket ore are used for grinding in place of pebbles. The ratio of tube mill to stamps tends to increase, and in recent practice is one 22½ by 5½-ft. tube mill to ten 2000-lb. stamps, or one tube mill to 200 to 250 tons per day of 3-mesh product. The following table is representative of modern work. Opinions differ as to the merits of a shorter tube mill. Scoop discharge has shown its advantage, as ex-

	+60 0.01 in., Per Cent.	+90 0.006 in., Per Cent.	−90 0.006 in., Per Cent.	−200 0.0025 in., Per Cent.
Entering table mill:				
Main circuit	85.81	8.08	6.11	....
Sand return	58.30	30.87	10.83	....
Leaving tube mill:				
Main current	18.74	23.58	57.68	....
Sand return	10.59	31.52	57.89	....
Final pulp before slime separation	1.40	13.87	84.73	....
Sand (39 per cent. of total ore)	9.28	38.76	40.94	11.02
Slime (61 per cent. of total ore)	....	....	10.00	90.00

[1] *Bull. Amer. Inst. Min. Eng.*, **101**, May, 1915, p. 997; **108**, Dec, 1915., p. 2436.

plained elsewhere. The standard generally adopted is the production of sand, −90-mesh. Schmitt spiral feed is the best. Tonnage varies from 250 to 400 tons per 24 hr., depending on coarseness of feed. Moisture content of feed is between 32 and 40 per cent. Reduction of speed to 28 r.p.m. in place of 32 to 33 is favored, the low speed giving an average peripheral speed of 400 ft. per min. using Osborn liner. The majority of the mills use Osborn liners with tapered bars 4 by 1¼ to ¾-in. section wedged in with flat bar 2½ to 3 in. wide and ½ to ¾ in. thick. The latest design of tube mill used by Rand mines has a ball chamber between the main crushing section and the outflow trunnion. This chamber has a cast-iron step lining and contains about twenty 10-lb. steel balls whose function is to crush the small spent pebbles, which would otherwise find their way out through the discharge trunnions.

Results in fine grinding by the use of the stamp-Chile mill-tube mill sequence at the mill of the Churchhill Milling Co. at Wonder, Nev., have been given by E. E. Carpenter.[1]

The eight tube mills at the Belmont Mill at Tonopah, are 5 by 18 ft. and grind about 65 tons each per 24 hr.[2] The feed is from 60 stamps with 4- and 6-mesh screens, and contains 69.5 per cent. on 100-mesh and 76 per cent. on 200-mesh; the product from the tube mills contains 71.9 per cent. on 200-mesh, but the final ground product issuing from classifier overflow contains only 27.7 per cent. on 200-mesh. Tests of the tonnage showed that of the 127.38 tons passing through the tube mill in 24 hr., 67.18 tons was initial feed and 60.20 tons return feed. Two tube mills are driven by one motor by double Morse chain drive. Power required is 98 to 127 hp. per mill. Silex block lining cost $395.84, lasted 8 months and cost 4.8 cts. per ton milled, or 5.83 cts. per ton actually ground. Komata manganese-steel lining cost $1784.59, ran 16⅔ months and cost 6.4 cts. per ton actually ground. Then new ribs were installed at a cost of $273.04 which prolonged the life of lining about 10 months and made the cost 4.57 cts. per ton. Belmont ribbed liner, of hard white iron, cost $710, is estimated to wear 2 years at a cost of 1.73 cts. per ton ground. Danish pebbles are considered to be more economical in the end than French, Newfoundland, or local Manhattan pebbles. The best pebble load is a little over half full, and 39 per cent. moisture in the feed gives highest grinding efficiency.

A novel arrangement of tube mills and drag classifiers was made at the Aurora gold mill. Two tube mills were connected by means of pinion gears and silent chain drives to the same motor. One mill was started first and its momentum helped to start the other without over-

[1] *Bull. Amer. Inst. Min. Eng.*, **102**, June, 1915, p. 1317. *Min. Eng. World*, **42**, 1066 (1915); *Met. Chem. Eng.*, **13**, 813 (1915).

[2] A. H. Jones, *Bull. Amer. Inst. Min. Eng.*, **104**, Aug., 1915, p. 1731.

loading the motor. By extending the drag classifiers and using large scoop feeds on the tube mills, the return elevators were eliminated.

The advantage of the closed circuit and a high tonnage in tube milling seems to have been pretty definitely settled by W. B. Easton.[1] Using a quick-discharge mill he found that the power used in crushing decreased as the moisture content decreased, covering a range of from 67 per cent. moisture down to 30 per cent., and it is believed that if a thicker pulp could have been obtained the power would have been still less. With no return from the classifier, that is practically an open circuit, the tube mill ground 144 tons of 6-mesh feed per 24 hr., with 40 per cent. moisture, so that 92 per cent. of product passed 100-mesh and the motor took 75 kw. With closed circuit and a feed of 240 tons per 24 hr. with 38 per cent. moisture, the motor took 62 kw. At another time, a feed of 180 tons with 38 per cent. moisture, took 70 kw. Reducing the moisture to 30 per cent. reduced the power to 65 kw. When the feed was 350 tons per 24 hr. and had 40 per cent. moisture, only 55 kw. were required. Unfortunately, the author does not make it clear whether the tonnages given are those in tube-mill circuit or tonnages of finished classifier overflow, but presumably the former. Detailed figures of tons of finished products and sizing tests would be desirable for backing up the author's conclusions.

The tonnage passing through a tube mill following stamps, where the tube mill and classifier are in closed circuit, may be determined from sizing tests using the following formula:[2]

$$\frac{T}{B} = \frac{d - a}{c - b}$$

a, b, c and d being the per cent. undersize of any given screen say 200-mesh, a for the stamp product, b for the tube-mill feed, c for the tube-mill discharge, and d for the classifier overflow. B is the dry tonnage of the stamps and T the dry tonnage of the tube mill.

The above formula also shows the ratio between tonnage ground and the tonnage circulating in the tube-mill circuit. Discussion of this ratio and of the use of a closed circuit in general, together with effect of moisture content of pulp, has resulted from its publication.[3] The conclusions reached are similar to those of Mishler.[4]

For feeding tube mills at the Waihi Grand Junction mill, a horizontal pipe or nozzle is used extending from the bottom of a feed cone.[5] In

[1] *Met. Chem. Eng.*, **13,** 89 (1915); *Jour. Chem., Met. Min. Soc. So. Afr.*, **16,** p. 87 (1915).
[2] N. Cunningham, *Min. Sci. Press*, **110,** 16 (1915); *Met. Chem. Eng.*, **13,** 22 (1915); *Jour. Chem., Met. Min. Soc. So. Afr.*, **15,** 280 (1915).
[3] J. H. Haynes, H. B. Lowden, A. H. Jones, W. J. Pentland, N. Cunningham, *Met. Chem. Eng.*, **13,** 10, 70, 71, 138, 204, 205, 826 (1915); *Jour. Chem., Met. Min. Soc. So. Afr.*, **15,** 280 (1915); *Mex. Min. Jour.*, **20,** 435 (1915).
[4] Mineral Industry, **23,** 817.
[5] N. Carliss, *Inst. Min. Met. Bull.*, **127**; *Met. Chem. Eng.*, **13,** 389 (1915).

the smaller mills, the feed nozzle is 1¼ in. inside diam. The nozzle discharges into a larger pipe which is bolted on to the end of the tube mill. A clearance space of ⅛ in. is left between the outside of the nozzle and the larger pipe; hence the pulp discharging into the mill causes a current of air to enter between the two pipes, thus preventing any chance of overflow of pulp at the inlet end. It has been found that the best results take place when the pulp passing into the tube mill contains about 40 per cent. moisture. Experimental work is in hand with a view of introducing thicker pulp into the mills.

In connection with the discussion of quick discharge devices given last year,[1] it is interesting to note that South Africa, with its characteristic thoroughness, has made extensive tests on these scoop discharges of various diameters applied to the regulation long tube mill.[2] Lack of space will not permit tabulation of these tests. They show, however, that increasing the diameter of the scoop gives increased capacity to the mill, but the mechanical efficiency, that is, tons ground through 90-mesh per 24 hr. per hp., although changing but little, reaches its maximum at 24 in. diam. The increase in capacity amounts to about 20 per cent. With ordinary trunnion discharge a 5½ by 22-ft. tube mill averages about 120 tons of product through 90-mesh per 24 hr.; with scoop discharge 24 in. diam. the tonnage through 90-mesh becomes 143 with proportional increase in power consumption. Increase of pebble load above the axis of the mill is of little assistance since the power consumption and wear of pebbles and liners go up out of all proportion to the tonnage. The effect of moisture in the feed and the size of feed has been considered, but the effect of variation in speed of the mill to conform to the changed conditions of pulp level in the mill does not seem to have been taken into account.

In general it would appear that the poor results obtained with increased pebble load and small sand feed, might be remedied by increasing the rate of feed and perhaps also varying the speed.

Results of tests on an experimental tube mill are reported by H. A. White.[3] The investigation was made with the view of determining what design and what adjustments would lead to the greatest efficiency. The factors considered were dimensions, speed, character of lining, variations in loads, size of feed, amount of feed, moisture in feed and size of pebbles.

Comparison of tube mills with Hardinge mills in a mill where both work side by side, has led to the conclusion that there is very little

[1] MINERAL INDUSTRY, **23**, 811.
[2] W. R. Dowling, *Jour. Chem., Met. Min. Soc. So. Afr.*, **15**, 214, 234 (1915); **16**, 57, 71 (1915); *Met. Chem. Eng.*, **13**, 874 (1915).
[3] *Jour. Chem., Met. Min. Soc. So. Afr.*, **15**, 176, 206, 270, 292 (1915); *Can. Min. Jour.*, **36**, 375, 396 (1915).

difference in efficiency and results. The truss principle of the cone, however, is structurally stronger, and the end steel castings of cylindrical mills are liable to give trouble by breaking unless properly designed and carefully made.

The relative merits of Hardinge ball mills and stamps have been brought out by N. Cunningham[1] in discussing the milling practice at Porcupine. The Vipond and McIntyre mills use rolls followed by Hardinge ball mills for the work done by stamps in other mills. The power per ton ground is higher with stamps but steel consumption appears to be slightly in favor of stamps; cost of operation and repairs, as well as first cost and uniformity of operation, are all in favor of the ball mill. The balance seems to be decidedly in favor of the ball mill.

The possibility of using Hardinge mills for both grinding and amalgamating has been the subject of considerable discussion. This will be referred to later under "Amalgamation."

A. F. Taggart[2] has given details of work, including sizing tests, of Hardinge mills in many localities.

The Britannia tube-mill lining, used successfully at the Britannia mill, consists of 2½ to 3½-in. sections of old rails set on end in cement and backed with old screen or expanded metal to distribute internal forces. The cement should come to within 1 in. of the top of the rail sections.[3] This lining when tried at the Miami mill proved too costly as it had a tendency to fall out and necessitate relining inside of 4 months. The Miami Co. is using a lining of manganoid steel plates faced with projecting lugs and ribs.

The Anaconda Co. is using the Forbes liner in tube mills. This liner has pockets in which pebbles may lodge, much like the El Oro, but it has the advantage over the El Oro that the back plate is removable and may be used again. The step form of liner, such as is used in Marcy mills, is favored for pebble mills also by some millmen.

A. J. Herald[4] reports the use of a lining of old shanks of gravity stamp shoes set in cement. He also summarizes the various forms of liners that have been used in tube milling.

Suggested uses for old worn-out tube-mill liner bars are as launder liners (filled in with cement), facings for battery bins and chutes, and linings for stamp mortars.[5]

The scarcity of imported pebbles, owing to the war, has turned attention to local substitutes, and to the use of metal balls. Ideal

[1] *Bull. Amer. Inst. Min. Eng.*, **99**, Mar., 1915, p. 601; **101**, May, 1915, p. 1141; *Can. Min. Inst.*, **18**, 100 (1915); *Min. Mag.*, **12**, 235 (1915); *Can. Min. Jour.*, **36**, 103 (1915); *Met. Chem. Eng.*, **13**, 187 (1915); *Min. Sci. Press*, **110**, 365, 754 (1915).

[2] *Bull. Amer. Inst. Min. Eng.*, **103**, July, 1915, p. 1365.

[3] *Eng. Min. Jour.*, **99**, 239 (1915); *Jour. Chem., Met. Min. Soc. So. Afr.*, **16**, 88 (1915).

[4] *Jour. Chem., Met. Min. Soc. So. Afr.*, **15**, 237 (1915).

[5] W. R. Dowling, *Jour. Chem., Met. Min. Soc. So. Afr.*, **16**, 21, 94 (1915).

pebbles should be spherical, dense, tough and hard, and not too large. Flint is the best material although quartzite and granite may be used.[1]

The U. S. Geological Survey has published a list of localities in the United States where flint pebbles occur.[2] Newfoundland graywack pebbles are in use at Cobalt. At the Arrowrock dam in Idaho, lava chunks were used and cost $2 per ton against $26.25 per ton for Danish pebbles.[3] Beach pebbles from San Diego County, Cal., are used in grinding cement.[4]

The pebble problem, with special reference to the Tonopah district, has been discussed by J. A. Carpenter.[5] Danish pebbles, which are best of all, are divided into eight sizes between 1 in. and 7 in. in diam., the sizes most in demand being Nos. 3, 4 and 5 ranging from 2⅜ to 4 in. These cost about $35 per ton at Tonopah, and the pebble consumption per ton in three mills of the district is between 4.2 and 4.7 lb. per ton, although in the West End mill it runs up to 7.1 lb. average. French pebbles are softer, cost a little less per ton of pebbles and wear faster. Newfoundland pebbles break along their fracture planes. Pieces of hard mine ore, which are used with good results in two tube mills at the Tonopah Mining Co.'s mill, eliminate the cost of pebbles but decrease the efficiency of crushing. Steel balls weigh nearly three times as much as pebbles, require more power, give greater capacity, and the abraded iron does no harm in the subsequent cyanide treatment. One pound of steel balls is equivalent to 3 or 5 lb. of pebbles. Artificially rounded onyx pebbles from Manhattan cost $19 per ton at Tonopah. Tests in the West End mill with smooth liners show wear ratio of Manhattan and Danish pebbles is 1.05:1; cost per pound ratio 0.95 ct.:1.73 ct.; cost per ton ground ratio $1:$1.75.

At the Miami Copper mill in Arizona, each section has two primary Hardinge conical mills 8 ft. by 22 in., crushing to 14 mesh, and one Hardinge 8 ft. by 66 in., for re-grinding to 48-mesh. Using pebbles, the capacity per section is 700 tons. The use of manganoid balls (cast iron containing manganese) 2 in. in diam. has increased the capacity to 900 tons. Further increase is limited by lack of power which prevents full loads of balls. The 8-ft. by 22-in. mill has a load of only 7 tons of balls, whereas it should have 13 tons.

Manganese balls are also used successfully in tube mills at the Butte and Superior mill, and in Hardinge mills at Anaconda, and show a saving over pebbles. The latter mill is experimenting with copper balls.

[1] E. C. Eckel, *Min. Sci. Press*, **110**, 103 (1915).
[2] G. O. Smith, *U. S. Geo. Survey Bull.*, **599**, 38; *Min. Eng. World*, **42**, 417 (1915).
[3] *Min. Sci. Press*, **110**, 259 (1915).
[4] *Min. Sci.*, **72**, 43 (1915).
[5] *Min. Sci. Press*, **110**, 139 (1915); *Min. Mag.*, **12**, 174 (1915).

Theory of Crushing.—A few further points have been made in the Kick *vs.* Rittinger controversy.

A. O. Gates[1] has published an amplified and clarified account of his experimental work which favors Rittinger, such variations as occur being credited to the effect of very fine particles which cannot be measured.[2]

The long series of tests at McGill University on full-size machines are reported to be finished and in line for publication. Advance information is to the effect that the Stadler-Kick theory of Energy Units is untenable, and that the Rittinger theory is borne out by the actual results.[3]

A. Del Mar[4] has made a few tests on artificial cubes and finds that the results bear out the Rittinger theory.

H. C. Kenny[5] has published a theoretical mathematical discussion and arrives at results favorable to Rittinger. Kenny's conclusions have been criticised by W. J. Rose[6] who takes issue with some of his assumptions.

A. F. Taggart[7] has calculated the mechanical efficiencies of Hardinge ball and pebble mills in actual use in various localities. His work is all based on the Stadler method of Energy Units.

The heat developed in crushing in a stamp mill has been determined by James Cook,[8] the object of the tests being to obtain information as to whether this heat could possibly indicate the energy used. Results of different tests were very consistent, and showed that of the actual power input to the motor, about 60 per cent. is returned as heat in the crushed pulp. Of the energy stored in the lifted stamp about 80 per cent. is returned as heat in the pulp, the remaining 20 per cent. being assigned to (*a*) loss by friction in guides, (*b*) loss in sound and vibration, (*c*) loss in radiated heat and (*d*) energy with which the pulp is delivered through the screens. The first factor would seem to be the largest. Morison[9] found that friction of guides and water amounted to 17 per cent. with carefully lubricated guides. Just what proportion of this is guide friction and what is water friction can not be said, but guide friction would seem to account for the most of it. Any water friction would be delivered to the pulp in the form of heat, but guide friction would not, except as conducted through the stamp stem to the water in the mortar.

In discussing these tests, Stadler points out that unfortunately they can not be taken as a criterion of the useful work done in crushing on

[1] *Bull. Amer. Inst. Min. Eng.*, **105,** Sept., 1915, p. 2023.
[2] MINERAL INDUSTRY, **23,** 823.
[3] *Bull. Can. Min. Inst.*, **42,** 744 (1915); **44,** 923.
[4] *Min. Sci. Press*, **110,** 677 (1915).
[5] *Min. Sci. Press*, **110,** 572 (1915); *West. Eng.*, May, 1915, p. 476.
[6] *Min. Sci. Press*, **111,** 39 (1915).
[7] *Bull. Amer. Inst. Min. Eng.*, **103,** July, 1915, p. 1365.
[8] *Bull. Inst. Min. Met.*, **124, 126;** *Met. Chem. Eng.*, **13,** 190 (1915); *Eng. Min. Jour.*, **99,** 976 (1915).
[9] *Richard's Ore Dressing*, **1,** 219.

account of the wasted energy in the form of heat produced by agitation of the pulp, by the friction among the particles, by the deformation of the ore within elastic limit and by rebound of stamp.

Comparison of rock crushing tests is often impossible, owing to the varying conditions under which the different tests are made. To avoid this difficulty M. K. Rodgers has suggested a standard set of specifications for making tests.[1] The need of such standard is indicated by the fact that the one factor of toughness of the rock has been shown by actual tests to affect the crushing duty of a unit of power as much as 300 per cent. To complete this scheme it is necessary to decide upon a standard unit of crushing, that is, to settle the present Kick *vs.* Rittinger controversy.[2]

The work of various crushing and grinding machines has been discussed by L. D. Mills and M. H. Kuryla before the International Engineering Congress.[3] Costs for coarse crushing by breakers to 1 or 2 in., including conveying, range from 4.6 cts. to 11.3 cts. per ton; stamping costs 10 to 30 cts. per ton; tube milling costs from 1.2 cts. to 50 cts. per ton, depending on the fineness of the product, the 50-ct. cost being at the Nipissing mill where the entire product will pass 200-mesh.

In summarizing crushing practice J. I. Wile[4] divides ores into ordinary ores and tough ores. The breaking for ordinary ores is done by iron Blake-type or gyratory breakers to 1½ in., or to 3½ in. followed by Symons disc to 1½ in. For tough ores use steel Blake-type breakers to 1½ in., or 3½ in. followed by Symons disc to 1½ in. For crushing ordinary ores from 1½ in. use ball mills to 10-mesh product or rolls to 4-mesh or Symons disc to ⅜ in. while on tough ores use heavy stamps to 3-mesh product or disc to ⅜ in. For the final step of grinding with feed ⅜ in. to 3-mesh and product through 30- or through 300-mesh use tube mills. Gyratories are complicated and have high repair costs and are succumbing to large Blakes except where the ore is soft. Symons disc-crushers are giving excellent results. One set of manganese steel discs gave a life of over 170,000 tons at the mill of the Detroit Copper Co. A 48-in. disc-crusher won out against 72- by 20-in. rolls for the Chile Copper Co. This crusher received feed of which 20 per cent. was between 4 and 6 in., 50 per cent. 2 to 4 in. and 25 per cent. 1 to 1.5 in. The crusher opening was 1¼ in. and the product had 78 per cent. 0.5 to 1.5 in. and 22 per cent. under 0.5 in. The capacity was 100 tons per hr. and the power 29 to 47.9 hp. Comparison by means of estimated figures shows that for secondary breaking from 3.5 to 1.5 in. the disc-crusher has

[1] *Bull. Amer. Inst. Min. Eng.*, **105**, Sept., 1915, p. 2053; *Min. Eng. World*, **43**, 365 (1915); *Min. Sci. Press*, **111**, 711 (1915); *Min. Mag.*, **13**, 281 (1915).
[2] *Eng. Min. Jour.*, **100**, 772 (1915).
[3] *Met. Chem. Eng.*, **13**, 721 (1915); *Can. Min. Jour.*, **36**, 647 (1915); *Internat. Eng. Cong.*, 1915.
[4] *Eng. Min. Jour.*, **99**, 691 (1915).

advantage over rolls or gyratories in original cost, weight and running cost.

For crushing 1.5-in. feed, the ball mills of the Marcy type have advantage over stamps except where the ore is so hard as to make high iron consumption. On medium ore it is estimated that 150 stamps costing $35,000 at factory would be required to crush 1000 tons daily from 1.5 in. to 10-mesh at a cost of 13 cts. per ton, and with the use of 360 hp., while two 7 by 4.5-ft. ball mills costing $6000 would do the same work at a cost of 7 cts. per ton and with 180 hp. If rolls are used in place of stamps it is doubtful if they can get down to a 7-ct. running cost and their first cost is higher. Where the crushing is to be carried to 4-mesh for table work rolls have the call, but if the crushing is to ½ or ⅜ in. for jigging, then the Symons disc is largely used.

For the final grinding in tube mills it has been found that shorter tube mills are as efficient as long mills and that by the use of quick-discharge devices the capacity may be increased and the product made coarse and granular for wet concentration. The feed to these grinders is as coarse as ⅜ or even ½ in. in some mills.

Screening, Classifying and Settling

Grizzlies.—A new type of grizzly for the Hercules mill, Idaho, is a travelling belt with slots between cross-bars. Another form used by the Magma Copper Co. consists of several large discs fastened at regular intervals on a revolving shaft. The whole thing acts like a roller feeder, except that only the coarse lumps are fed forward, the fines falling down between the discs.[1]

Screens.—Screens of the Impact type are found in many mills, instead of fine trommels. Favorable reports are made of them and their use appears to be on the increase. Some Callow belt screens are found. One Utah mill had difficulty with a 3-mm. Callow screen which had a tendency to break after short service. The cause was that the regulation pulley was too small and made the bend too short.

A novel arrangement in a Butte mill is to do away with Impact screens feeding undersize to Wilfley tables, and to attach horizontal screens of the same mesh directly to the table just above the feed corner.

A gently inclined screen, shaken on the Ferraris principle, has been developed at Morenci. This screen has a sluice deck close to the underside of the screen. Clogging is prevented by the coarser part of the undersize striking against oversize particles in the screen holes and driving them back. Raised inclines on the sluiced deck force the down-

[1] *Eng. Min. Jour.*, **99**, 241 (1915).

flowing water to pass back and forth through the screen and increase the efficiency of screening. For use with acid water, all parts coming into contact with the water are of wood, copper or rubber, and the screen itself is of bronze.[1]

Round vs. Square Holes.—The question of the relative size of product from round-hole screen, to that from square-hole screen is an important one, especially in comparing coal screens, which are usually round-hole, with ore screens, which are more often square-hole. Results of several tests by H. A. Roesler[2] on different ores, give a fairly constant ratio of 1.23, that is, the undersize of 1-mm. square-hole will be the same as the undersize of 1.23-mm. round-hole.

Classifiers and Settling Tanks.—The use of the Dorr mechanical classifiers and Dorr thickeners is constantly on the increase in ore-concentrating plants. The classifier originally used in gold mills to separate sand and slime is now used almost universally to return coarse particles wherever tube-mill grinding is applied. It also finds extensive application for dewatering concentrates and tailings. The thickener, too, was formerly limited to gold mills, but its value is now appreciated wherever any slime material is to be dewatered. The flotation process has given it a great boost since it is conceded to be the best device for thickening the slime before flotation, as well as for recovering the concentrates after flotation. The work of this machine will be referred to again later, under flotation. J. V. N. Dorr has published details of both of these pieces of apparatus and of the work that they are doing.[3]

The most ambitious Dorr thickener recorded to date is that of the Arizona Copper Co.[4] This consists of a circular concrete retaining wall resting on the ground and supporting a circular track for carrying the outer ends of the travelling arms. This dewaters the fine mill tailings and supplies clarified water to be used over in the mill. It is 130 ft. diam., 4 ft. deep at periphery, 8½ ft. at center, makes 2 to 3 revolutions per hr., has 13,000 sq. ft. of settling area, receives pulp containing 5.93 per cent. solids equivalent to 700 tons dry solids per 24 hr., delivers discharge with 30.65 per cent. solids, and makes a water recovery of 85.75 per cent. Power required is 4.7 hp. and repair cost is 0.2 ct. per ton of dry solid. The discharge could be thickened to 50 per cent. solids, but it is not advisable to do so because this material has to be flumed 2 miles before being used as mine filling. This thickener is working under its capacity, which is estimated to be double or treble its present rate.

At the Nevada Consolidated mill the Dorr tanks are merely excava-

[1] D. Cole, *Bull. Amer. Inst. Min. Eng.*, **98**, Feb., 1915, p. 443.
[2] *Eng. Min. Jour.*, **99**, 493 (1915).
[3] *Met. Chem. Eng.*, **13**, 55, 91 (1915).
[4] D. Cole, *Eng. Min. Jour.*, **100**, 131 (1915); *Min. Mag.*, **13**, 163 (1915); *Metall und Erz*, **12**, 428 (1915); *Genie Civil*, **47**, 173 (1915).

tions in the ground 70 ft. diam. with concrete collar around the rim to form an overflow weir and also to support the trusses which carry the mechanism.[1]

Modern practice in the use of settling tanks and filtering boxes, together with results of tests of various salts for slime settling, has been described by G. Nicolai.[2]

Theory of Settling.—The velocities of particles falling in liquids have been determined by P. Schulz,[3] using a moving-picture machine and more refined measurements obtained than was ever possible before. The advantage of this method is that velocities may be determined for very short spaces of time. Results show that the falling particles very soon pass through the acceleration stage and come to uniform velocity. For various spheres falling in water the resistance factors have almost constant values which correspond very closely to theoretical values, but the opposite is the case in paraffin oil. The limiting velocity for spheres in water is affected by the smoothness of surface. Other factors must be taken into consideration in the case of oil. For viscous liquids, the laws of settling have to be modified. Values of constants and of friction have been worked out for various shapes of different minerals in various liquids for application in the formula $C = a\sqrt{\frac{D(d - d')}{d'}}$ where C is velocity, a is a constant, D is diameter of particle, d is specific gravity of particle and d' is specific gravity of liquid. Some changes are shown from the old Rittinger constants, although it should be said that these changes are not great, thus giving great credit to the carefulness of Rittinger's work with a cruder method. The article is replete with details of operation and results and discussion of these results, especially in comparison with those of other observers.

Hand-sorting, Jigs and Tables

Hand-sorting.—In describing present practice of sorting gold ore in South Africa, F. L. Bosqui[4] reports that the annular picking table has been almost entirely superseded by belts of canvas or canvas and rubber, 30 to 40 in. wide, inclined upward about 10° and slightly concave, to allow draining and prevent spill. Belts are cheaper to install and operate and have the further advantage that they elevate and convey the ore while it is being sorted. The capacity per belt is between 50 and 100 tons per hr. according to width. The new sorting plant of the Rand mines, Ltd., is expected to be a model embodying all the latest improvements and facilities.

[1] *Met. Chem. Eng.*, **13,** 717 (1915).
[2] *Metall und Erz*, **12,** 135, 155 (1915).
[3] *Gluckauf*, **51,** 457, 481, 510, 540, 562 (1915).
[4] *Bull. Amer. Inst. Min., Eng.* **101,** May, 1915, p. 997; **108,** Dec., 1915, p. 2436.

Jigs.—Hancock jigs for treating at one operation material ranging from 1.5 to 10 mm. in size, are standard in Missouri lead mills and are used in one section of the Anaconda mill. With the present tendency toward simplification of mills, their use should increase.

Riffle Tables.—The Butchart riffles[1] have been the subject of a paper by D. Cole[2] who goes into the details of their development, their action and their possibilities. The special advantages of tables with these riffles are that they can take coarse feed up to ¼ or ⅜ in. by using deep riffles up to 1-in. depth, no classification is necessary or even desirable, except possible desliming and the table is less sensitive. The curve at the end of the riffles is very important, especially on coarse feed.

The far-reaching possibilities of this table, with its high capacity in the way of simplifying flow-sheets do not appear to be appreciated. It replaces in one single operation, the work formerly done by fine trommels, fine jigs, hydraulic classifiers and tables. The only tables in the new flow-sheet of the Anaconda mill, given later, are Butchart.

In one of the Missouri lead mills, formerly a classifier, six primary Wilfley tables, and one middlings table were required to do the work now done without classification by two primary Butchart and one middling Butchart. The Butchart arrangement does work equal to the former arrangement.

For special purposes the manufacturers of the Wilfley tables supply special riffles.[3] One form has three riffles extending parallel with, and the full length of, the lower edge of the table. Above these the riffles which perform the main work of stratification, are laid inclined slightly uphill, terminating in a diagonal line, and every alternate one is extended a few inches at a smaller inclination toward the concentrates end of the table. These also end in a diagonal line except those on the lower half of the table which continue to the end of the table. Three wooden cleats on the table top near the feed box are essential for proper distribution and stratification of the pulp. This table will give finished products and will treat five times as much unclassified sand feed as earlier models.

At Silverton, Colo., Wilfley tables 12 ft. wide and 45 ft. long are used as roughing-tables and handle a very large tonnage of old tailings that are being re-treated. The feed is classified into coarse and fine and both are fed to the same table—the coarse at the feed box, and the fine near the discharge end.

For unclassified feed every third or fourth riffle can be made higher,

[1] MINERAL INDUSTRY, **23**, 827.
[2] *Bull. Amer. Inst. Min. Eng.*, **98**, Feb., 1915, p. 431; **101**, May, 1915, p. 1123; *Met. Chem. Eng.*, **13**, 332 (1915); *Mex. Min. Jour.*, **20**, 284 (1915); *Min. Sci.*, **71**, Apr., 1915, 51.
[3] *Met. Chem. Eng.*, **13**, 819 (1915).

thus producing a pond or lake in which stratification can be made more effective.

For coal washing the Wilfley-table riffles extend horizontally the whole length of the table top. A table 7 by 16 ft. will handle 4 to 6 tons of coal per hr., through ¼-in. ring.

Many other modifications of riffles will be found in travelling through the mills. The Timber Butte mill on some of the tables has a set of regular Wilfley riffles ending on diagonal line, and then a second set which are practically short extensions of the first set running diagonally down the table; on other tables a few of the riffles are extended to the end of the table. An arrangement somewhat similar to the former is used in one of the Coeur d'Alene mills where long riffles are laid on the lower portion of the smooth part of the table. These make a very slight angle with the diagonal end line of the regular riffles and extend to the end of the table and cause a wider band of concentrates.

Apparently the advantage of the Butchart and other types of inclined riffles, lies in the action of the wash water which, instead of passing directly across the riffles, flows down more or less in the grooves and in the same direction as the grooves, and thus washes the gangue away from the concentrates. The upward incline of the Butchart appears especially favorable since this downward action of the water on the gangue is supplemented by the bump of the table which forces the concentrates uphill.

On the Wright concentrating table used for concentrating complex lead-zinc ores in Sardinia, the height of riffles has been gradually cut down and spacing reduced so that the riffle is 3 to 4 mm. high, 6 mm. wide, spaced 15 to 20 mm., center to center, and tapered only near the ends.[1] The riffles on the upper half of the table end on a diagonal line, but those on the lower half end on a curved line, which effects a wider fan of concentrates, forces the middlings farther down the table, and makes a sharper and better separation between the concentrates and middlings. The low riffles closely spaced spread out the sand bed which covers the fine concentrates and ultimately allows them to travel to the concentrates end. For slimes, grooves cut 2 to 3 mm. deep and 6 to 8 mm. apart in the linoleum table top are preferable to cleats. These have ending similar to those on sand tables.

Vanners.—Vanners have received a hard blow from flotation, and likewise round tables. Very few vanners are to be found now in Missouri lead mills. The Utah Apex mill has discarded them entirely for flotation. The porphyry copper mills like the Utah Copper have removed

[1] *Eng. Min. Jour.*, **100**, 641 (1915).

many of them and seem likely to do away with them altogether. On Butte ores they are practically obsolete.

Round Tables.—The Anaconda 20-deck round tables which seemed almost new, have had their day and have gone to the scrap heap because they saved only 65 per cent. of the copper against 90 per cent. by flotation. It should be said, however, that during their period of activity they paid for themselves several times over, and that the settling tanks used for preparing their feed and for receiving their concentrates are just as suitable for flotation.

For a rough surface on revolving round tables W. Morley Martin is trying out on Cornish tin slimes, frosted glass and fluted frosted glass, the frosting being obtained by sand blast.[1]

Theory of Spigot Discharges.—Knowledge of the rate at which a mixture of sand and water will flow through an opening is of importance in designing classifier spigots. The governing factors are: size and form of openings, head of water, ratio of sand to water, size and specific gravity of grains and ratio of size of grains to size of opening. The relation may be expressed by the formula

$$a = \frac{fq}{c\sqrt{2gh}}$$

where a is area of spigot opening, f is the viscosity of the mixture, q is the ratio of discharge by volume, c is the coefficient of discharge (0.59 to 0.63 for sharp-edged orifices, 0.85 to 0.95 for the usual bell-shaped intake opening on classifier spigots), g is the acceleration due to gravity and h is the head of water above the spigot. Results of a few experiments are reported by R. H. Richards and B. Dudley, Jr.,[2] which were made on a siliceous material 1.4–0.1 mm. in size, for the purpose of obtaining values for f. It was found that the viscosity f increased from 1 for pure water, up to 1.23 for a mixture containing 27.6 per cent. sand by weight or 12.3 per cent. by volume. A mixture of over 30 per cent. by weight is so thick that it will very soon clog the spigot and cease to flow.

AMALGAMATION

Amalgamated plates are still used in the mills on the Rand in South Africa, although their area has been somewhat reduced in some cases. The plates are commonly fixed and are placed after tube mills, although some plants still use them after stamps. This whole subject of amalgamation in South Africa, including details of operation, has been discussed by F. L. Bosqui.[3]

[1] *Min. Mag.*, **12**, 86 (1915); **13**, 341 (1915).

[2] *Bull. Amer. Inst. Min. Eng.*, **97**, Jan., 1915, p. 67; **101**, May, 1915, p. 1122; *Met. Chem. Eng.*, **13**, 120 (1915); *Jour. Chem., Met. Min. Soc. So. Afr.*, **16**, 11 (1915).

[3] *Bull. Amer. Inst. Min. Eng.*, **101**, May, 1915, p. 997; **108**, Dec., 1915, p. 2436.

A most excellent detailed account of South African clean-up practice, as applied at the Simmer Deep mill, has been given by W. H. Jane and F. Davey.[1]

Details of amalgamation and recovery of bullion at the Homestake mills are reported by A. J. Clark.[2]

In analyzing the practice at the Dome and Hollinger cyanide mills at Porcupine, the former using amalgamation and the latter not, N. Cunningham is of the opinion that the results are in favor of the Hollinger practice.

The use of blankets for catching free gold is still in vogue at the Golden Cycle mill at Colorado Springs. High-grade telluride ore from Cripple Creek is crushed dry in ball mills, roasted and ground wet in Chile mills and run over blankets. These catch 50 per cent. of the gold recovered, the remainder being recovered by cyanide. The blankets are washed every 6 hr. and the washings amalgamated in an iron arrastra followed by a Wheeler pan and a clean-up pan.

Regarding amalgamation in Hardinge mills, conflicting reports have been made showing success in some mills and not in others, and considerable discussion has resulted.[3] The final conclusion appears to be that the violent action of a pebble mill is not a hindrance to accompanying amalgamation. Success or failure may be caused by varying conditions, most of which may be controlled. It is especially important that the mercury be kept bright and be fed in sufficient quantity to make soft amalgam.

At the Plymouth Consolidated and the Amador Consolidated mills in California, the Hardinge mills each have a Hardinge amalgamator attached to and revolving with the mill. It consists of a miniature Hardinge mill surrounding the usual cylindrical chip screen at the discharge end of the mill. It contains about a dozen small copper balls made up of ¼ or ⅜-in. copper wire. Mercury is fed into the amalgamator. The wire balls build up and form good-sized balls of amalgam which are removed daily.[4]

The Plymouth Consolidated and Argonaut mills also use the Plymouth amalgamator.[5] It consists of a wooden box 6 ft. long, 18 in. wide, divided into two compartments 12 and 6 in. wide respectively. It is given a shaking motion longitudinally of 200 2-in. strokes per min. by an Isbell vanner head motion. Pulp flows first over the wide compartment which has an iron bottom covered ¼ in. deep with mercury.

[1] *Jour. Chem., Met. Min. Soc. So. Afr.*, **16**, 67 (1915).
[2] *Bull. Amer. Inst. Min. Eng.*, **103**, July, 1915, p. 1381; **108**, Dec., 1915, p. 2453.
[3] F. J. Gerard, M. W. von Bernewitz, H. W. Hardinge, J. W. Pinder, F. O'Boyle, G. R. Pringle, *Min. Sci. Press*, **110**, 110, 261, 338, 450, 610, 828 (1915).
[4] T. S. O'Brien, *Eng. Min. Jour.*, **100**, 256 (1915).
[5] L. A. Palmer, *Met. Chem. Eng.*, **13**, 617 (1915).

Thence it passes over the narrow compartment which has a regular amalgamated plate on the bottom. The work of this apparatus is reported to be very efficient.

Some tests on efficiency of amalgamated plates by F. A. Thomson and R. Keffer[1] show catching power of amalgams on pure quartz ore as follows: plain mercury, sodium, lead, silver, tin, zinc, cadmium, gold. When sulphates of iron, zinc or manganese were present the order was: lead, tin, plain mercury, sodium, silver, zinc, cadmium, gold. The position of gold amalgam as poorest catcher of gold is very questionable. In ability to remain bright the order was: cadmium, lead, tin, gold, silver, sodium, zinc, plain mercury.

These do not appear to be conclusive for millmen, because in actual work the efficiency of an amalgamated plate over a period of several hours is the standard instead of during a short test.

The making of an amalgamation test is commonly looked upon as a simple operation. W. J. Sharwood,[2] however, points out the possibilities of error, which may occur in following the directions given by various authors, which he summarizes, and gives detailed instructions for making gold-free mercury and for designing the apparatus and actually performing the test.

For a complete recovery of pure mercury which goes into amalgamation residues at Cobalt in the form of sulphide, E. B. Thornhill[3] reports the use of a solution of 1 per cent. sodium hydrate and 4 per cent. sodium sulphide as a solvent, followed by granular aluminium as a precipitant.

Magnetic Concentration

The new magnetite concentrating mill at Mt. Hope, N. J., crushes the ore to 2 in. by gyratory-breakers, dries it in a Rowand tower-drier, sizes it by trommels and runs it over Ball Norton magnetic separators. Both the drum and pulley types of machine are used for coarse stuff, while the belt type is used for stuff below 5/16 in. Middlings are re-crushed in four separate sets of rolls and re-treated.[4]

The Moose Mountain No. 1 plant at Sellwood, Ont., seems much simpler by comparison since the only trommel is 1⅜ in. through which the ore is crushed. Everything ranging from 1⅜ in. to 0 goes direct to modified Ball Norton drum separators which makes concentrates and tailings. Concentrates are ready for blast furnace except that fines are removed by ⅛-in. trommel. Tailings have a middling product taken out

[1] *Met. Chem. Eng.*, **13**, 367 (1915); *Metall und Erz*, **12**, 250 (1915).

[2] *Bull. Amer. Inst. Min. Eng.*, **104**, Aug., 1915, p. 1659; *Met. Chem. Eng.*, **13**, 927 (1915).

[3] *Bull. Amer. Inst. Min. Eng.*, **104**, Aug., 1915, p. 1653; **108**, Dec., 1915, p. 2455; *Can. Min. Inst.*, **18**, 94 (1915); *Min. Sci. Press*, **110**, 873 (1915); **111**, 211 (1915); *Min. Eng. World*, **43**, 329 (1915); *Met. Chem. Eng.*, **13**, 330, 873 (1915); *Min. Mag.*, **12**, 293 (1915); *Min. Sci.*, **72**, Sept., 1915, p. 42.

[4] S. Shapira, *Eng. Min. Jour.*, **99**, 559 (1915).

by a stronger magnet before going to waste. This middling product and the fines go to No. 2 mill.[1]

For separating pyrite from tin concentrates at Llallagua, Bolivia, the material is first roasted in a Kauffman furnace, run without any fuel except that of the burning sulphur and over half of the sulphur burned off. The roasted material is then treated by Stern wet magnetic separators which make tin concentrates and a magnetic-iron product which is re-ground in Huntington mill, classified and tabled to recover a small amount of additional cassiterite.[2]

The Wetherill magnet used at East Pool in Cornwall yields a wolframite concentrate containing considerable cassiterite. It was found that these two minerals were cemented together by iron oxide, and that by pickling for 12 to 14 days at 180° F. in a 11 per cent. sulphuric acid solution, disintegration took place. After this treatment the material, when run again over the Wetherill magnet, yielded a high-grade tungsten product as well as a high-grade tin product.[3]

Separation of blende and siderite at the Gennamari-Ingurtosu mine in Sardinia formerly accomplished by roasting and Primosigh drum magnets, is now more cheaply and efficiently done by Ullrich magnetic separators without any preliminary roasting.[4]

Pneumatic Concentration

Sutton, Steele and Steele tables and Stebbins tables are used in the Yellow Pine district of Nevada. On easy concentrating ores these dry tables appear to do fairly good work, but dust losses are high and their use would not be recommended where water is available. An unsized feed is desirable on the Stebbins table, the fine particles being necessary to fill in the interstices between the larger particles and thus prevent the air from escaping up through the bed without doing its proper work of keeping the ore in suspension.

Flotation Processes

Growth and Present Status.—The tremendous increase in the use of flotation during the past year has turned attention universally to this subject. It is impossible to cover all that has been done and written, and the reader is therefore referred to bibliography at the end of this article and also to a separate article in this volume which treats the subject more from the theoretical side, while this review aims to cover

[1] B. B. Hood, *Eng. Min. Jour.*, **99,** 973 (1915).
[2] D. Copeland and S. E. Hollister, *Eng. Min. Jour.*, **100,** 513 (1915); *Min. Mag.*, **13,** 287 (1915).
[3] M. T. Taylor, *Min. Mag.*, **12,** 351 (1915).
[4] C. W. Wright, *Eng. Min. Jour.*, **100,** 911 (1915).

the practical details. Rickard's estimate is 20,000,000 tons treated by flotation in the United States in 1915, with the prospect of a 50 per cent. increase in 1916. Whereas, 2 years ago few flotation plants existed, today there are very few districts milling sulphide ores in which flotation is not used, with a resulting increase in extraction ranging all the way from 10 to 30 per cent., depending on the character of the ore. The most striking exception is the Southwest Missouri zinc district. Tests have shown that these zinc slimes are readily floated, but the small size of the mills in that district makes flotation commercially unattractive. A combination of mills operating a common flotation plant will undoubtedly be the satisfactory solution. The occurrence of lead with the zinc may be another deterring factor. Only one failure of flotation is noted, that at the Daly-Judge mill where it was impossible to separate the lead from the zinc. Straight pyrite ores containing no values but sulphur are not floated, probably because the fine flotation concentrates would be undesirable for sulphuric acid manufacture.

The extent to which flotation has caused changes in mills amounts in some cases almost to reconstruction. For example, the Anaconda Co. is spending $6,000,000 for mill and smelter changes, the greater part of which are due to the introduction of flotation. The mill recovery is increased from 78 per cent. to 91 per cent. The Gold Hunter mill in Idaho, described later, scrapped $20,000 worth of machinery to introduce flotation, which increased recovery from 55 per cent. to 80 per cent. The porphyry copper mills like the Utah Copper are throwing out whole floors of fine tables and vanners. Former recoveries of about 65 per cent. are increased 20 or 25 per cent., or up to 85 or 90 per cent.

Beside sulphide ores the process has shown possibilities on native and oxidized ores. Successful flotation of free gold is reported. Lake Superior native copper slimes can be floated by the use of pine oil and it is expected that the White Pine Extension mill treating extremely finely divided native copper in shale will be a straight fine grinding and flotation plant with perhaps a few tables to save the coarsest copper around 60-mesh. Scheelite may be floated, but other tungsten ores have resisted flotation to date.

Oxide and carbonate ores, especially of copper, are a problem which is receiving considerable attention. Many mines, more especially the porphyry copper mines, have considerable of this oxidized material mixed with the sulphides. A very small amount of this is floated ordinarily with the sulphides. The most successful work on this material is being done by the so-called "filming process." Since the surface of a particle governs its floating qualities, the introduction of a sulphiding agent, such as hydrogen sulphide, or sodium sulphide, will cause particles of oxidized copper ores to float on account of the chemical reaction by which a film of sulphide is formed on the surface of the particles. The latter reagent is already in commercial use in several mills with satisfactory results, although the concentrates obtained by this method are low grade. There are indications that as our knowledge of flotation increases, we may be able to float oxide ores almost as successfully as sulphides.

Another problem is the separation of lead-zinc ores by flotation. The Horwood roasting process used successfully in Australia on zinc slimes is not in use in the United States, although some companies have experimented with it. Possibly the cost is too high. The Bradford process which prevents the flotation of the zinc by the addition of sulphur dioxide compounds has found no commercial application to date. Allen H. Rogers reports that galena will float in an iron agitating cell using a 10 per cent. solution of soda ash and aeration. The zinc which is not floated in the iron cell is recovered later in a brass agitating cell using eucalyptus oil. What is being done commercially in the United States is more or less along the line of the Lyster process assisted by tables. For example in some mills in the Coeur d'Alene district using Callow cells the galena is floated first by adding a small amount of creosote and no acid in a hot solution and covering over all but about one-third of the cell. In later cells the zinc is floated by adding acid and more creosote. Both the lead and the zinc concentrates are dirty and require further treatment on Deister tables to make them cleaner. In one mill the Wyman hot sulphuric acid process followed by Franz table is used on lead-zinc-iron middlings. At the Timber Butte mill zinc-lead flotation concentrates go to James tables. Other mills like the Butte and Superior and the Morning, aim to get out all the lead possible by jigs and tables before flotation. None of these processes are doing entirely satisfactory work, but the millmen are sanguine that they are on the right track and will ultimately produce a satisfactory separation. The chief difficulty with the Lyster method of preferential or selective flotation, is that it is a delicate operation, and although galena is more easily floated than blende, and although a fairly good separation may be made in the laboratory by careful adjustments, yet in mill work it is difficult to keep the quantity and quality of the pulp sufficiently uniform to float all the galena and at the same time not float any blende. J. M. McClave reports that on some ores he has obtained a good separation of lead and zinc by tabling flotation froth, where only a poor separation was possible on the same material before flotation.

Application to Mill Flow-sheets.—Analysis of flow-sheets shows that there are six ways in which flotation is applied to mills as follows: (1)

On slimes alone. This is illustrated by the Southeast Missouri lead mills which save all they can on jigs and riffle tables and use flotation only to handle muddy water and slimes too fine to have their values recovered

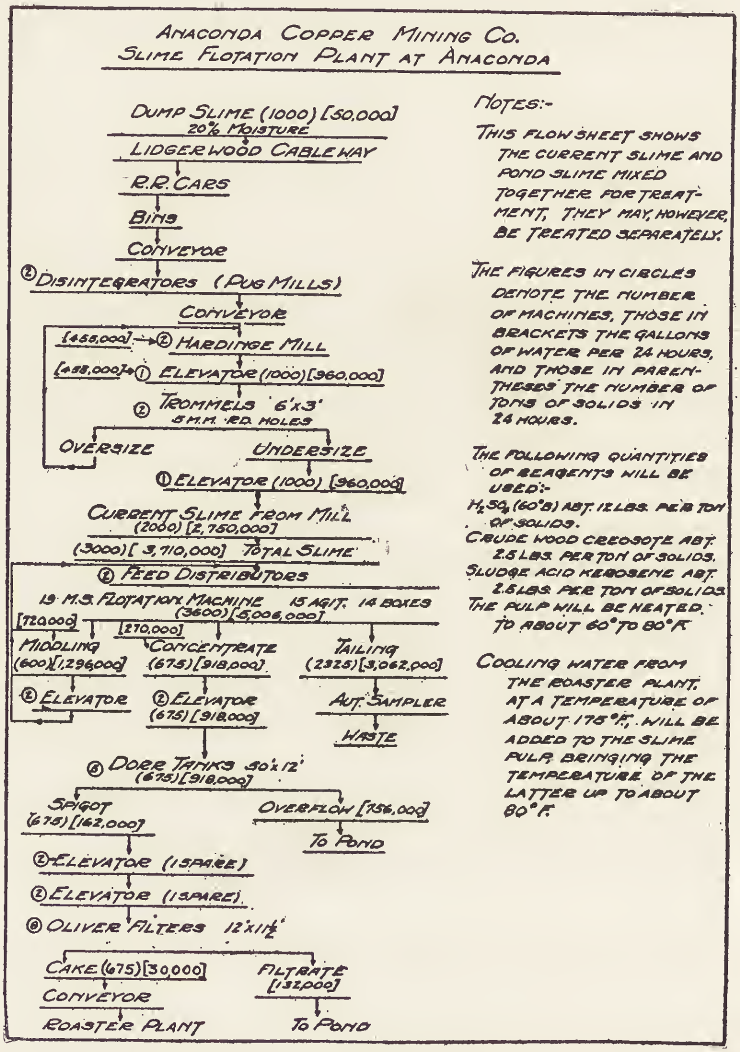

Fig. 1.—Flow sheet, Anaconda mill.

on riffle tables. Only canvas tables, slime vanners and slime tables have been discarded. (2) *On mill slimes and more or less re-ground tailings.* This scheme is perhaps the most used. The millmen have found that the cheapness of flotation allows a profit from re-grinding tailings which formerly went to waste, and floating them with the slimes. The Coeur d'Alene district has examples of this, ranging from mills which re-grind very few of the tailings to the Gold Hunter mill, described later, which re-grinds all its tailings for flotation. The Utah Copper, Nevada Consolidated, Ray and Chino, also have been changed so that they re-grind the greater part of the tailings. The Anaconda, Timber Butte and Miami mills send all their tailings through flotation. Some mills are using flotation to clean up the concentrates made on slime vanners, but this may be regarded as a temporary expedient as there would seem to be no reason for using both vanners and flotation where the latter alone will do the work. (3) *On tailings formerly thrown away.* The Nipissing mill at Cobalt finds that a profit can be made from re-grinding cyanide tailings assaying about 4 oz. silver per ton and floating them so that final tailings assay only 1 or 2 oz. per ton. The Buffalo and McKinley-Darragh mills at Cobalt have re-grinding and Callow flotation doing about this same work. (4) *On old tailings dumps.* Many small plants have sprung up for re-grinding and floating old dumps, some of which have been exposed for years. The Utah Leasing Co.'s mill on the old Cactus dump, described later, is an example of what can be done at a total cost of only 55 cts. per ton. Many of these dumps have been oxidized by standing, but it is found that the oxidation is only superficial and that re-grinding exposes fresh sulphide surfaces. Of course there is some loss from the oxidation, as is shown at the Leadville District mill where flotation on fresh tailings will reduce the zinc in the flotation tails down to 1.5 per cent., while on old tailings it can not be reduced below 5 per cent. (5) *As the main mill process.* The Inspiration mill, given later, uses tables only to catch the coarse particles that escape flotation. The Ozark mill at Magdalena, N. M., uses flotation alone to save zinc in an ore containing blende, magnetite, specularite, hematite, galena, chalcopyrite, pyrite and pyrrhotite in a lime and tremolite gangue. The Engels mill, described later, also uses only flotation to separate copper sulphide from magnetite and gangue. In these last two cases, table concentration is impossible on account of the presence of heavy waste minerals, but where these are not present, the all-sliming and flotation process is questionable unless the ore is very finely disseminated. A particle caught by jig or table is 100 per cent. saved, but if this same particle is ground to slime, probably not over 90 per cent. of it will be saved. The deciding factor will be whether this 10 per cent. loss is greater or less than the saving in interest and operating charges of the simpler and cheaper flotation mill. (6) *For gold and silver ores as an adjunct to cyaniding.* The Independence mill at Cripple Creek is reported to be using flotation to recover the rich tellurides which are not easily cyanided. Where copper minerals occur in a gold or silver ore, flotation is used to take them out and leave a residue which can be cyanided without excessive cyanide consumption. Flotation is cheaper than cyaniding, and in the case of a gold or silver ore carrying practically all its values associated with sulphides, the logical step would appear to be first concentrate by flotation, especially where the percentage of concentrates is low, and then cyanide the concentrates. Unfortunately, to date, flotation concentrates have not been found to be amenable to cyaniding, probably on account of the re-precipitating action of the accompanying oil, but this difficulty does not seem unsurmountable. Naturally, flotation products for cyaniding should preferably be obtained from a neutral or alkaline pulp.

Processes and Apparatus.—Practically all flotation plants in America use the so-called froth process. The Potter-Delprat and DeBavay of Australia have received little attention here, although the Wyman hot acid cell used somewhat in the Coeur d'Alene seems to have some points in common with these processes. The same is true of the Murex magnetic process used in Europe. No Elmore vacuum plant exists in the United States, as far as known; there is one plant in Mexico and another was running in Quebec until last year, when it burned. It has been replaced by a mechanical froth plant. The Elmore patent rights for the United States are reported to have been bought by the opponents of the Minerals Separation Co. Of the surface tension, or skin flotation methods of Macquisten and Wood, the use of the Macquisten tube is still confined to the Morning mill, while the Wood machine is used chiefly on experimental work in Denver. One Wood machine is located at a copper mine in Vermont. The Saunders process, employing basic aluminium sulphate solution in circular iron pans, is in use at the Empire Zinc mill at Magdalena, N. M., and also a plant at Marion, Ky. The Ozark process at Magdalena, N. M., may also be classed as a surface-tension process. Ore ground so that 50 per cent. will pass 200-mesh is mixed with acid and oil and fed upon the surface of hot water moving in a tank. Blende floats, while most of the pyrite and pyrrhotite together with heavy oxides and gangue sink. A 95 per cent. recovery is made by successive treatments of an ore assaying 16 per cent. zinc. The concentrates assay 45 per cent. zinc.

The froth processes fall into two divisions: (1) those using mechanical agitation, such as the Minerals Separation, Janney and similar types, and (2) those using pneumatic agitation as in the Callow cell and its modifications.

The Minerals Separation cell is shown in Fig. 1. This is a section of a double cell made up of two single cells back to back. The single cells are connected in series according to the Minerals Separation method of joining the bottom of one Spitzkasten by pipe to the bottom of the following agitating cell. The number of cells in series varies, 8, 12, 16, 20 and 24 being common numbers. The figure shows the agitating cell 3 ft. square, but cells 2 ft. square are in common use and some are as small as 16 in. Usually the first cell, and frequently the second cell in the series are emulsifying cells, having no spitzkasten and delivering no froth, although occasionally these emulsifying cells are omitted. The standard method of driving is by bevel gears from a common line shaft running along the top of the cells. Sometimes the agitators are driven by quarter turn horizontal belts from a common line shaft. Speeds have been noted ranging from 265 to 390 r.p.m., some ores requiring higher speed than others. The power consumption increases rapidly with the speed. A 16-in. cell at 280 r.p.m. takes about 4 hp. A 24-in. cell at 265 r.p.m. takes about 3 hp. At Anaconda a 150-hp. motor drives sixteen 3-ft. cells at 225 r.p.m. The Minerals Separation cells are commonly made of wood. Their capacity is variable. At Anaconda, a 15-cell machine treats 400 tons of sand per 24 hr. of which 90 per cent. will pass 60-mesh or 175 tons of slime of which 95 per cent. will pass 200-mesh. In Missouri lead mills a machine of 16 or 20 cells averages about 250 tons per 24 hr. on slime which is largely finer than 200-mesh. It is reported that 28 licenses to operate under Minerals Separation patents were in effect in 1915.

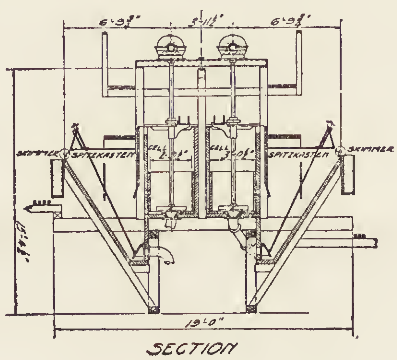

Fig. 2.—Minerals Separation cell.

The Minerals Separation people also put out the Hebbard subaeration cell. This has a double spitzkasten and is in use in the mill of the Utah Leasing Co. The agitator makes 425 to 450 r.p.m. and 130 cu. ft. of air per min. at a pressure of 5 lb. per sq. in. is supplied at the base of each agitating compartment.

The Janney cell is used in the Butte and Superior mill, in several of the porphyry copper mills and in some other mills. The cells are commonly of iron and each cell is driven from above by an independent vertical motor. The agitating compartment is circular and 24 in. in diam. Pulp sucked in from the spitzkasten through openings at the bottom, overflows the top of the agitating compartment and passes under a baffle into the same spitzkasten of which there are two on each cell one on each side of the agitating cylinder. Each spitzkasten is about 4 ft. square at the top, and the slope of the inclined bottom is somewhat gentler than in the Minerals Separation cell. Connection between the successive cells in a machine is obtained by an adjustable opening connecting adjacent spitzkasten. Since the flow is by gravity, each successive cell is set lower than its predecessor. A vertical cross-dam in the spitzkasten prevents pulp from entering one side of the spitzkasten and passing out the other without entering the agitating cell. The number of cells in series in a machine is usually less than in the Minerals Separation machine, being commonly 10 or 15 and the speed is higher, running up to 570 r.p.m. at which speed each cell consumes 10 hp.

Other forms of mechanical agitation cells are in use such as the Copper Queen horizontal cell and the Bunker Hill and Sullivan cell which has no agitating compartment, but uses two centrifugal pumps to obtain the necessary agitation between successive spitzkasten.

The Callow pneumatic cell, although the youngest of the flotation cells, has been received with marked favor during its 2 years of existence. In the last half of 1915, 50 Callow cells were reported operating in the Coeur d'Alene district treating 1500 to 2000 tons of slimes daily and 680 cells in the entire country handling 25,000 to 28,000 tons daily. For further description and discussion of this cell see the special article on Flotation following.

Arrangement of Cells.—Recent practice has been toward complexity, introducing additional cells for re-treating tailings and cleaning concentrates. The simplest arrangement is that of the Callow rougher and cleaner, or that of mechanical agitation where each cell makes a finished concentrate. The froth which comes off first is always the richest. The first deviation comes where froth from later cells is a middling to go back to the feed of the first cell. Often considerable muddy water is taken off with this middling. Further deviations lead to more complicated arrangements which may change more or less from day to day. For example the Timber Butte mill with Minerals Separation cells worked as follows on one day: (1) 11 rougher cells in series. Froths 1 to 6 went to intermediate cells; froths 7 to 11 with considerable water went to Akins classifier, making sand to be re-ground in tube mill and sent back to rougher again and slime going directly back to rougher; tails of 11th cell were waste. (2) 5 intermediate cells in series. Froths 1 to 3 went to cleaner; froths 4 and 5 and the tails returned to intermediate; (3) 8 cleaner cells in two sets, the feed being supplied to Nos. 1 and 5. Froths 1, 2, 5 and 6 were finished concentrates; froths 3, 4, 7 and 8 returned to cleaner; tails of 4 and 8 returned to intermediate.

Many millmen state that between roughing and cleaning the froth must be well broken up in order to be cleaned satisfactorily and the dilution should be greater on the cleaner cell than on the rougher.

Kind and Amount of Oil.—Although a great many oils and combinations of oils have been tried, still when the mill figures are analyzed it is found that comparatively few oils are in actual use and the tendency is more and more toward simplification and cost reduction. Pine-oil appears to be an almost universal flotation agent giving a high-grade concentrate. Wood-creosotes are considered to be nearly as good. Eucalyptus is excellent but expensive. The petroleum products while cheaper, do not seem to be able to make so clean concentrates as the wood products, and therefore are more used on copper ores where high-grade concentrates are not so necessary. There is also a question regarding a sufficient supply of pine-oil to do all the flotation in the United States. Oils in actual use are pine-oil, pine-tar oil, turpentine, wood-creosote, eucalyptus-oil, coal-tar, coal-tar oil, cresylic acid, carbolic acid, creosol, crude fuel-oil, stove-oil, kerosene acid sludge. For lead and zinc ores, pine and wood-creosote are in common use, while for copper ores a base of coal-tar or crude-oil is common to supply the body to the froth to which is added small amounts of light frothing oil. The use of coal-tar is comparatively recent, but most coal-tars are found to be satisfactory and are favored on account of their low price. The approximate costs are: pine-oil, 25 to 30 cts. per gal.; eucalyptus-oil, $1.50 to $2.00 per gal.; wood-creosote, 18 to 25 cts. per gal.; petroleum products, 5 to 10 cts. per gal.; coal-tar, 5 cts. per gal.; creosol, 30 cts. per gal. The amount of oil used varies from 0.5 to 4 lb. per ton of ore treated, average about 1.5 lb. Since the cost of the various oil mixtures actually used varies from 1 to 3 cts. per lb., it can be figured that the cost of oil for flotation ranges from 2 to 10 cts. per ton treated.

Following examples illustrate practice. Southeast Missouri lead mills use only creosote varying in amount from 1 to 2.5 lb. per ton. Coeur d'Alene use mainly pine. Pine is also used on Butte zinc ores at the rate of 1.5 lb. per ton, and in the Daly-Judge mill 0.4 lb. per ton. One Coeur d'Alene mill uses either eucalyptus or pine. On copper ores the Inspiration uses 1.5 lb. per ton consisting mainly of crude coal-tar with some coal-tar creosote and a small amount of light frothing oils. The Consolidated Arizona formerly used various mixtures of coal-tar, coal-tar creosote, creosol, pine and carbolic acid, but now uses about 1 lb. per ton of ore consisting of 2 parts stove-oil and 1 part No. 200 oil (refined wood-creosote). One porphyry copper mill uses about 0.3 lb. per ton of a mixture which is about one-half coal-tar, one-quarter creosote, one-eighth pine and one-eighth creosol. Another uses

4 lb. consisting of one-half crude and one-half creosote with a little pine added occasionally when the froth is poor. The Gold King mill on pyrite, blende and galena uses 0.7 lb. per ton of carbolic acid, creosote and pine. The carbolic acid is added in the pump before the first cell, the creosote is added to the first cell and the pine to the fourth cell. Anaconda uses 2 to 3 lb. of kerosene sludge acid (containing 50 to 60 per cent. sulphuric acid) per ton and 0.5 to 1 lb. of crude wood-creosote. About 0.03 to 0.05 lb. of the wood-creosote is added in the Hardinge mill and the remainder in the sixth agitating compartment. The control of the oil in flotation is very important. It frequently happens that cells will suddenly go wrong for no apparent reason and can be restored to normal only by readjusting the oil. Different shipments of what is supposed to be the same grade of oil will frequently give different results.

The addition of the oil is rarely all at the first cell, although the major part of it is put in here. Wherever possible, it is advisable to add some of the oil in the grinding machine. In a Missouri mill on lead slimes with 24 cells, oil was added on cells 1, 5, 8, 11, 14, 17 and 21, but more on No. 1 than on all the rest together. For feeding the oil, cans with drip cocks are used somewhat, but can not be depended on for even feed. Oilers of the forced-feed lubricator type give very satisfactory results. The Anaconda and some other mills use a small bucket-wheel elevator lifting from a tank of oil, the speed being regulated by an adjustable friction pulley and disc drive.

Use of Acid, Alkali and Salts.—There is a noticeable decrease in the use of sulphuric acid. Formerly 10 to 20 lb. per ton of ore was a common figure but now the range is from 4 to 10 lb. Anaconda uses 6 to 8 lb. and the Timber Butte 7 to 8 lb. On many zinc and lead ores acid is unnecessary. Missouri lead mills use no acid and many mills in the Coeur d'Alene also. Acid was found to be fatal on Miami copper ore. Some mills have found better results with alkali than with acid, for example the mill on the Cactus dump, given later. Mills using filming process with sodium sulphide for oxide copper ores naturally use alkaline solutions.

The use of electrolytes is as yet in its infancy. A Tennessee zinc mill found that copper sulphate was essential to success. Another western zinc mill was able to reduce acid from 8 lb. down to 4 lb. per ton by the use of copper sulphate in the proportion of 0.6 to 0.8 lb. per ton of ore. It is the belief of the writers that as the fundamental theory of flotation is better understood the use of salts to control the character of the pulp as an electrolyte will come more in vogue.

Temperature.—While better flotation and higher grade concentrates are usually obtained from hot solutions, still on account of expense and trouble of heating, few mills work with heated solutions, except for some special purpose. Prominent exceptions are the Anaconda mill which heats to 60° or 70° F. and the Timber Butte which heats to 130° F. It can be said that the most of the flotation of the country is done without heating.

Size of Grains Floated.—Mills floating only slimes are probably handling material which is finer than 100-mesh and in some cases finer than 200-mesh. One Missouri lead mill in this class reports that practically all its froth is finer than 200-mesh. When mills are regrinding material for froth flotation, common practice is to grind between 50- and 100-mesh maximum size with the expectation of floating the grains up to the maximum size. The Ozark mill grinds to 200-mesh, but this is on a finely disseminated ore. The Inspiration mill which grinds mostly through 48-mesh, with the expectation that the coarser particles will escape flotation and be caught on tables later, reports that flotation does catch some particles as coarse as 40-mesh.

The foregoing applies to froth flotation. The ability of the Elmore and Macquisten processes to save sulphides as coarse as 20- or 30-mesh is well known.

Preparation of Pulp.—A study of the mills shows that in most cases the pulp for flotation contains between 3 and 4 parts water to 1 part solid. Less water is required for sandy pulp and more for slime. Thus at Inspiration with sand as coarse as 48-mesh the proportion is 2.8 to 1. In the Missouri lead mills on slimes the proportions vary from 3 to 1 up to 7 to 1. Here there is a conflict of opinion, one mill reporting that 7 to 1 is best, while another mill, on similar material, reports 3 to 1 is best. Miami uses 6 to 1, Anaconda 3 or 4 to 1, Butte and Superior 3 to 1. The extreme case is the Old Dominion where the proportion ranges between 7 and 11 to 1 on account of the presence of fine iron oxides which make the ore difficult to treat and require a thin pulp for best results.

The problem of getting pulp of the right consistency is very simple where tube-mill grinding is used before flotation. The discharge from tube mills contains not over 40 per cent. moisture as a rule, and the dilution which takes place in passing the tube-mill discharge through a Dorr classifier can usually be adjusted to the flotation requirements. However, in the case of mills floating slime and muddy water the pulp is too dilute, even as low as 2 or 3 per cent. solids, and must be thickened before flotation. Occasionally Callow cones or common settling tanks are used for this operation but the Dorr thickener is the almost universal instrument. The size of Dorr tanks varies, but as will be seen by the three following examples, the water handled per square foot of surface area is approximately constant. The Anaconda mill Dorr tanks are 28 ft. diam. and 3 ft. deep. Each tank received about 15 or 16 tons of solid and 660 tons of water per 24 hr. This figures out about 2.3 per cent. solids in the feed and a capacity of 1.0 ton of water per 24 hr. per sq. ft. of surface. Similar figures for Miami 46 by 10-ft. tank are 200 tons solid feed, 2400 tons feed water, 8 per cent. solid in feed and 1.6 tons water per sq. ft. At a Missouri lead mill for a 40 by 8-ft. tank, solid feed is 92 tons, feed water 1000 tons, 8.4 per cent. solid in feed and 0.8 ton water per sq. ft. The underflow of Dorr thickeners can easily be regulated to give pulp of the required density for flotation.

Disposal of Froth.—The process of recovering the froth and removing its excess water has been pretty well standardized into the following steps: (1) Scraping froth from cell into launder; (2) breaking down the froth in the launder by water; (3) thickening in Dorr thickeners to 1 or 1.5 or even 2 parts solid to 1 part water; (4) filtering in Oliver vacuum filters down to 10 or 15 per cent. moisture, or sometimes in Kelly pressure filters to 6 to 10 per cent. moisture for shipment.

In the case of Callow cells and sometimes in the case of mechanical agitation cells the froth is thin enough to flow over the edge. In one or two mills scrapers are used on Callow cells and in most of the mills on mechanical cells. The scraper may be a single paddle or several paddles on a revolving shaft which pull the froth over the edge of the cell, or a belt with paddles which skims froth from the whole top of the spitzkasten.

In one or two cases water is not added to break down the froth, but the froth goes into an elevator which breaks down the greater part of it and delivers it with the table concentrates into filter bottom tanks. As the froth comes off the cells it carries from 10 to 30 per cent. water. Where water is added to break it down it will easily dilute it so that it contains from 60 to 90 per cent. moisture. This addition of water is a distinct disadvantage because this water must be removed later and it makes the pulp too thin to go direct to the filters. This water is sometimes a single jet, but several jets are more efficient and a spray is best of all. Continuing along the same line an atomized jet would appear to be even better than a spray. In small plants which are not warranted in going to the expense of thickening and filtering, and also in most of the Missouri lead mills, this dilute pulp is run into settling tanks about 10 by 15 ft. by 2 ft. deep, heated with steam pipes in the bottom. These tanks are run until nearly full of settled slime, then dried and shovelled out. This method is inefficient and expensive and is not to be recommended. One Missouri lead mill handles 10 tons of froth and 165 tons of water per 24 hr. in an 18.5-ft. Callow cone, making spigot product containing 1 part solid to 1 part moisture which is mixed with the jig and table concentrates. The Ozark mill sends the froth and water to Ovoca classifier which thickens it to a product containing only 20 per cent. moisture.

The Dorr thickeners for flotation concentrates are usually of large size and since it is almost impossible to break down the last traces of froth before these tanks, baffles are necessary to keep this froth from flowing over the edge. At the Inspiration mill, on a tank 65 ft. diam., there are two circular baffles, one about 30 ft. in diam. and the other very close to the periphery of the tank. Both baffles extend down about 2 ft. under water. At this mill two tanks are run in series. The feed comes to the first tank which has no overflow, but water is pumped through a side opening to feed the second tank at the center as usual. The second tank overflows clear water. Both tanks deliver a spigot product containing 1.5 parts solid to 1 part water.

For filters the Oliver vacuum type is favored, unless for special reasons a cake with less than 10 per cent. moisture is desired. The vacuum commonly used is about 17 to 22 in. of water. The feed to an Oliver filter can not contain less than 50 per cent. solids. If froth could be easily handled from the cell to the Kelly pressure filter without dilution the expense of Dorr tanks could be saved. The disadvantage of the Kelly filter is that it is cumbersome and expensive to operate. The following details of Dorr tanks and Oliver filters at Anaconda are representative practice. Froth broken down, containing 18 to 20 per cent. solids is delivered in a baffle box about 5 ft. square in the center of a Dorr tank 50 ft. diam. and 12 ft. deep. This baffle extends down to within a few inches of the rake arms. Surrounding this is another baffle about 15 ft. square and extending down about 18 in. below the surface of the water. These baffles catch most of the remaining froth which is broken up by a water spray. A little froth escapes and runs to slimes pond for future treatment. The capacity of a tank is 200,000 to 250,000 gal. of pulp per 24 hr. The spigot averages about 60 per cent. solids and is reduced by Oliver filter capable of delivering 150 tons of product per 24 hr. which will contain 15 per cent. moisture. These filters are 11.5 ft. diam. and 12 ft. face and have a little paddle-wheel agitator in the bottom of the tank to keep the solids from settling. A little dry steam is introduced with the air blow which removes the concentrates from the filter cloth.

Cost of Flotation.—Callow gives a cost for a 2000-ton Callow plant of 6.75 cts. per ton, made up of labor 1.25 cts., oil 2.50 cts., power 2.50 cts. and maintenance 0.50 cts. These figures include only the bare cost of the flotation operation. The Consolidated Arizona reports 27 cts. per ton, of which 2.8 cts. is for oil. This figure does not include royalty.

In Missouri lead mills, 30 cts. per ton includes all pulp thickening, flotation and handling concentrates.

In the large porphyry copper mills 20 to 30 cts. is the total estimated cost of flotation, including the fine grinding. The Inspiration reports entire milling cost exclusive of coarse crushing as 48.67 cts. per ton in 1915. The details of this mill are given later. The Utah Leasing Co. on the old Cactus dump handles the old tailings into the mill, grinds and floats them at a total cost of 55 cts. per ton including royalty. The increase in power accompanying the introduction of fine grinding and flotation is a considerable item. One porphyry copper mill reports that this increase in the re-arranged mill will amount to 150 per cent. of the former power consumption.

Future Possibilities.—Constant improvement in flotation is to be expected for some time to come. Up to the present everything has been empirical and results can be determined only by experiment. The operation is a sensitive and delicate one and small points such as uniform quality and quantity of feed, uniform dilution and uniform conditions in general are essential for success. The Callow process is said to be more sensitive than mechanical agitation and too much air will absolutely kill the flotation. Certain sulphates are reported to be very bad. One operator reports that at a certain season of the year when the mill water contains considerable organic matter the flotation efficiency falls off seriously. While it is not within the scope of this article to discuss theory, still it is the writers' wish to go on record as believing that such points as these can lead to only one conclusion which is, that when the fundamental principles of flotation are worked out they will be found to be based on the principles of static electric charges.

Accessory Apparatus

A handy chart for quickly determining the correct number of plies of conveyor belts operating under specified conditions has been worked out by J. D. Mooney and D. L. Darnell.[1]

M. G. F. Söhnlein has given some valuable points on the design and practical operation of belt elevators.[2]

Principles, Theory and General Ideas

Ideas regarding milling are undergoing a rapid change toward simplicity, as will be seen from a study of flow-sheets of new mills. Where the ore is not complex, crushing is finer and there are fewer coarse

[1] *Bull. Amer. Inst. Min. Eng.*, **105**, Sept., 1915, p. 1937; *Iron Tr. Rev.*, **57**, 1231 (1915); *Colliery Guardian*, **110**, 1032 (1915); *Eng. Min. Jour.*, **100**, 562 (1915); *Min. Eng. World*, **43**, 651 (1915).

[2] *Min. Sci. Press*, **110**, 485 (1915).

trommels and jigs. At the fine end, classifiers, vanners and similar slime machines are replaced by flotation. Some mills throw away no tailings except through flotation. In one or two cases there are hints of abandoning jigs and tables entirely and coming to all sliming and flotation, but such action would appear to be too radical and would lead to a reaction later.

The chief reason for these mill changes is, of course, flotation, but Butchart riffles have also had considerable effect.

A novel idea carrying simplification still further has been proposed by David Cole and involves the use of a frothing classifier, that is a classifier which combines classification and oil flotation, together with a Butchart table and a tube mill grinder in a closed circuit. Ore fed to the grinder would be delivered to the frothing classifier which would remove fine sulphide froth, and at the same time send fine sand to waste and coarse sand to the table. The table would remove coarse sulphides and deliver tailings containing mineral in the form of included grains back to the grinder. Thus nothing could escape from the circuit except as concentrates or as fine tailings.

Going more into details, points of improvement noted in recent design of milling plants are: (1) pan-feed conveyors under bins instead of gates; (2) increased use of belt conveyors, feeders and weightometers; (3) better arrangement of classifiers, dewaterers, etc.; (4) realization of importance of test mills.[1]

Considering mill construction, H. T. Curran[2] has supplied some detailed figures on costs. The cost of preliminary plans and preparation which will average to 5 or 10 per cent. of the total cost is often neglected. This includes calculation of all excavations and masonry or concrete, listing of everything going into construction, even down to nails, arrangement of hauling and handling facilities, preparation for storage house, framing yard, bunk house, etc.

Of erecting costs, superintendence including cost of plans, will amount to 3 to 5 per cent. of the total. Hand-excavation and moving 100 ft. costs 45 cts. per cu. yd., if wheelbarrows are used, or 35 cts. with mine-cars. Rock excavation by hand with 100-ft. haul costs $1.25 to $1.75 per cu. yd. Rubble masonry averages $5 per cu. yd. using cement mortar; concrete $7 to $10 per cu. yd. depending on the size of forms. Reinforced concrete using old iron costs 50 cts. more. Floors average $10 per cu. yd. Unloading and hauling will have a fixed charge of 30 to 40 cts. per ton and will increase with length of haul; probably 75 cts. per ton-mile is average on fairly good roads. Carpenter work with

[1] C. M. Avery and C. A. Tupper, *Min. Eng. World*, **42**, 1 (1915).
[2] *Eng. Min. Jour.*, **100**, 345 (1915).

well-organized crew will average $21 per 1000 bd. ft. for framing and erecting, $12 to $15 for siding and roofing and $2.50 per M for shingles or $0.75 to $1.00 per square. for corrugated iron. Erection of machinery costs about $45 per ton for heavy parts and $50 to $65 for concentrating machinery, classifiers, filters, etc., including carpenter work which is about one-third of the cost. Pipe work costs $40 to $45 per ton; erection of wooden tanks, about $12 per 1000 bd. ft. Steel mill frames can be erected for $12 to $15 per ton. Allowance of 10 per cent. of the total cost should be made for possible changes when the mill is started. The foregoing are only average figures for summer work. Winter conditions in northern latitudes can easily increase the labor cost one-third or even one-half.

Detailed costs of the building of the Tough-Oakes cyanide mill, Ont., are reported by J. A. Baker.[1]

Examples of Practice

The Inspiration mill with its radical change in practice started operation during the year. Other large mills such as the Anaconda, Utah Copper, etc., have made changes so extensive that they made almost new mills. Several small mills have come into existence especially in connection with flotation.

The Inspiration mill at Miami, Ariz., has a capacity of 14,000 tons per 24 hr. on porphyry copper sulphide ore.[2] The mine ore passes through the coarse crushing plant which is in three units, each unit having gyratory and Symons vertical breakers, and is conveyed to suspended bins having total capacity of 14,000 tons. There are 18 similar sections to the mill of which only one will be described.

Ore from bins, fed to (1).

1. Two Marcy ball mills 7 ft. diam., arranged end to end. Flotation oil added to mill feed. Although original feed is only 800 tons, there is about 1800 tons in circuit. To (2).

2. Two Dorr duplex classifiers, 24 r.p.m., set between Marcy mills so that each classifier receives feed from its mill and returns sand to other mill. Overflow, 2.8 water to 1 solid and all through 48-mesh, to (3).

3. Flotation cells. Arrangement varies in different sections. One arrangement is 24 rougher Callow cells and four cleaner; another two roughing machines of 16 Inspiration cells in series in each and two cleaning machines each having six Inspiration cells in series. Concentrates from rougher go to cleaner; tails from rougher go to (4); concentrates from cleaner go to (7); tailings from cleaner, with more oil added, go back to rougher.

4. One drag belt classifier. Sands to (5); slimes to (9).

[1] *Eng. Min. Jour.*, **100**, 869, 915 (1915).
[2] *Eng. Min. Jour.*, **100**, 1001 (1915).

5. Two Deister hydraulic classifiers with six spigots each. Spigots to (6); overflow to (9).

6. Eleven double deck Deister sand tables. Concentrates to (7); tailings to (9).

7. Four Dorr thickeners for whole mill, 65 by 12 ft. Two pairs with two tanks in series in each pair. Spigots 1.5 solid to 1 water, by four bucket elevators to (8); overflow clear water for mill.

8. Four Oliver filters, 12 by 12 ft., 10-oz. duck laid over burlap, suction equal to 17 to 19 in. water, 150 tons of cake per 24 hr. with 15 per cent. water delivered over steam-heated apron.

9. Three Dorr thickeners 100 by 10 ft., three 80 by 10 ft. and one 60 by 10 ft., for entire mill. Spigot to waste; overflow clear water for mill.

The mill is extremely compact for so large a capacity. The building is steel frame with corrugated-iron sides and roof and rubber-glass windows. Floors are of concrete and slope three ways in each section.

Feed averaged in 1915, 1.702 per cent. copper of which 0.226 per cent. was oxidized. Tails averaged 0.373 per cent. copper of which 0.18 was oxide. The flotation concentrates assayed 37.63 per cent. copper, the table concentrates 13.12 per cent., all concentrates 32.67 per cent. The extraction was 79.95 per cent. of total copper in feed; the extraction figured on sulphide alone was 88.56 per cent. The ratio of concentration was 24.6 tons into 1. Costs were 2.91 cts. per ton for coarse crushing and 48.675 cts. for concentrating including royalty.

The Anaconda mill in its remodelled form has a total capacity of 16,000 tons per 24 hr. or 2000 tons per section. A flow-sheet illustrating a single section, Nos. 2 to 8, is shown herewith and merits considerable study. The jig field extends from 2 in. down to 1.5 mm. Classifiers are used only for de-sliming. Only one set of Wilfley tables is used and these have Butchart riffles. All tailings are finally ground by Hardinge mills through 60-mesh and go to Minerals Separation flotation. Owing to insufficient space in the mill to float all the slimes, part of them go to a separate plant which also handles some old slimes from slimes pond. The flow-sheet of this plant is shown.

The No. 1 section of the mill differs from the others in omitting the 4-mm. trommel and feeding stuff between 3/8 in. and 1.5 mm. to Hancock jigs. Tube mills are also substituted for conical mills. All conical mills originally 10 by 4 ft. for pebbles have been reduced to 7.5 by 6 ft. by 15-in. wood lining faced with steel for use with steel balls as the grinding agent.

Fractional figures in circles on the flow-sheets mean that this is the portion of the mill equipment belonging to each section. For example, the entire mill has five Oliver filters and therefore 5/8 of a filter is assigned to each section.

The mill feed assays 2.85 per cent. copper, the slimes going to flotation

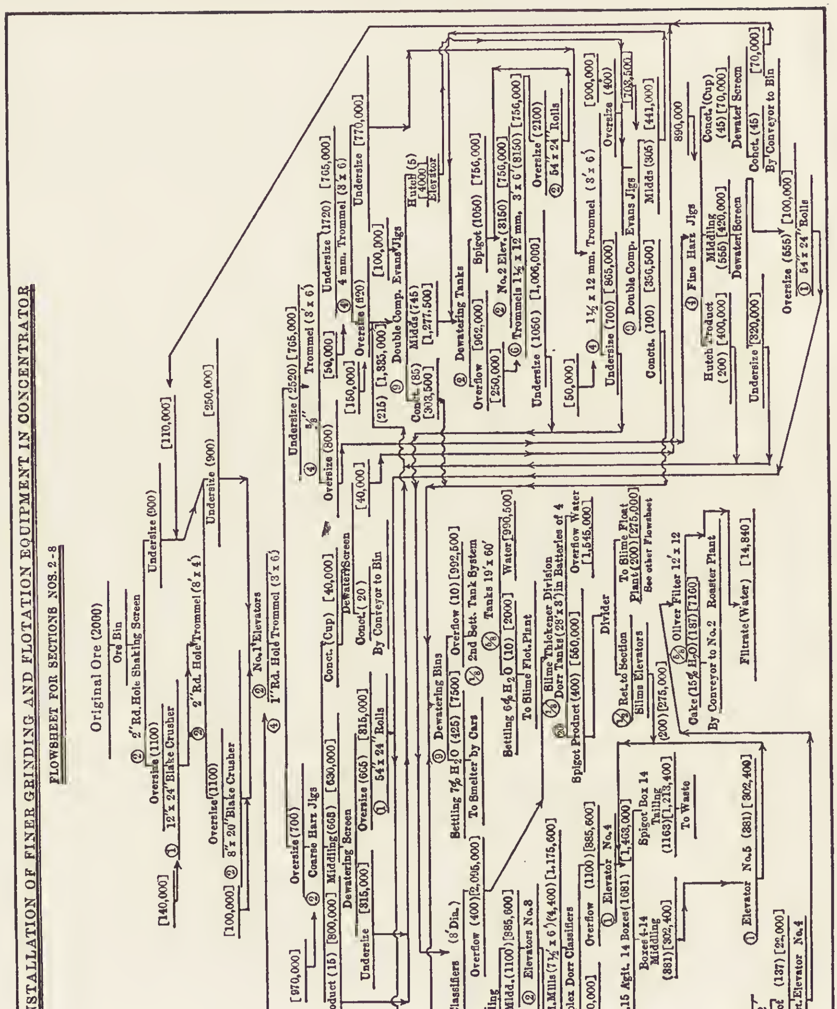

FIG. 3.—Flow sheet, Anaconda mill.

2.3 to 2.6 per cent., and the re-ground tailings to flotation 0.60 per cent. Tailings assay 0.13 per cent., formerly 0.60 per cent.; the sand tailings being 0.10 per cent. and the slime tailings 0.25 per cent. Concentrates assay 8 per cent. copper. Extraction has been increased from 78 to 91 per cent. and the capacity from 12,500 tons to 16,000 tons. The allowance for new construction in mills and smelters by the Anaconda Co. was $6,000,000, and it is estimated that the resultant annual saving will be $7,250,000. One effect of this saving will be an extension of the life of the mine owing to the possibility of treating lower-grade ores at a profit.

The Consolidated Arizona mill[1] is a good example of simplification of flow-sheet. This mill formerly had jigs, tables and vanners and saved 70 per cent. of the copper. The re-arranged mill crushes by breakers, rolls and Hardinge mills direct to table size. The crushed product is classified and concentrated on Butchart-Wilfley tables. All tailings and slimes, after thickening to about 2.5 parts water to 1 part ore, pass through one 11-cell Minerals Separation machine. The froth from all cells is concentrates except that of the last, which is returned to the feed. The underflow from the last cell is final tailing. This scheme gives a recovery of 90 per cent. of the copper. Of the total copper saved 75 per cent. comes from flotation and 25 per cent. from the tables. The mill treats 225 tons per day at a cost of about $1 per ton.

The Utah Copper mill remodelled section receives ore through 2-in. screen from coarse crushing plant and feeds it direct to Marcy ball mill. The product, of which half is finer than 48-mesh, goes to six Garfield roughing-tables each treating 80 tons in 24 hr. These rougher-concentrates are cleaned up by classifier and Wilfley tables into concentrates to smelter and tails to waste. The rougher-tailings are classified into coarse spigot back to Marcy mill, medium spigot to Chile mill and overflow to Janney flotation cells. The Chile mill product goes to three tables making concentrates to smelter and tailings back to Chile mill. The Chile mill and tables form a closed circuit from which nothing escapes except as concentrates or as classifier overflow. Thus all tails go to flotation except the small amount obtained from the cleaning of the rougher concentrates.

At the Nevada Consolidated mill in a remodelled section the ore from the breakers goes to Hardinge ball mills replacing coarse and fine rolls. The ball-mill product is classified, the coarse going to Wilfley tables and the fine to flotation. The Wilfley tailings are re-ground and go to flotation. The former fine Wilfleys and all vanners are discarded.[2]

[1] *Met. Chem. Eng.*, **13**, 897 (1915).
[2] *Met. Chem. Eng.*, **13**, 716 (1915).

The Braden Copper mill[1] in Chile is an illustration of gradual reduction until all tailings finally pass through the flotation plant. The successive steps are as follows: Grizzly and gyratory-breaker to 2 in.; rolls to 7/8 in.; trommel to remove oversize of 6 mm.; Symons disc-crusher reducing oversize of 6 mm. to 5/8 in.; Impact screens 6 mm. for Symons product; oversize of 6 mm. Impact screens crushed in coarse and fine rolls until it all passes through the screens; Impact screens and trommels, 5-mesh; oversize of 5-mesh Impact (through 6 mm. on 5-mesh) crushed in rolls and with all undersize goes to Wilfley tables; table tailings with oversize of 5-mesh trommels ground in Hardinge mills accompanied by drag classifiers; sand to second set of Wilfley tables and slime to flotation; tails from second set of Wilfley tables ground in second set of Hardinge mills until 90 per cent. passes 60-mesh and goes to flotation. Minerals Separation cells are used.

The Engels mill[2] in California is an example of an all flotation plant. The ore containing copper sulphide associated with magnetite and gangue is crushed by gyratory-breaker, rolls and 7 by 10-ft. tube mill until only 5 per cent. remains on 100-mesh. It is then fed to a 12-cell Minerals Separation machine which makes finished concentrates froth from the first three cells and middlings froth from the rest which is returned to the first cell for re-treatment. The concentrates are settled in a settling tank and then go to Oliver filter reducing moisture to 10 or 12 per cent. The filter cake is finally dried down to 5 or 6 per cent. in an old drag classifier heated by fire. Oil used is 0.4 lb. per ton of ore, half of which is added in the tube mill. Feed averages 3.8 per cent. copper and the concentrates 40 per cent. The extraction is 84 per cent. and the capacity 200 tons per 24 hr. The total cost of the mill was $50,609 plus freight. Table concentration is undesirable for the obvious reason that it would not separate the magnetite from the copper sulphide as the flotation does.

Utah Leasing Co.'s Mill.—This is an example of a flotation plant on an old dump. The old Cactus mill tailings in Utah amount to 1,000,000 tons.[3] This plant has a capacity of 500 tons per 24 hr. and consists of two 8-ft. by 48-in. Hardinge mills and two Dorr classifiers which furnish material all finer than 65-mesh to a 12-cell Minerals Separation flotation machine. The first six cells are regular single spitzkasten cells but the last six are Hebbard sub-aeration cells with double spitzkasten. The speed is 425 to 450 r.p.m. and alkaline solution is used as better than acid. The first three cells make froth concentrates, the remaining nine cells make middling froth which is returned to join

[1] *Min. Sci. Press*, **111**, 933 (1915); *Mex. Min. Jour.*, **20**, 429 (1915); *Eng. Min. Jour.*, . **100**, 894 (1915).
[2] T. T. Read, *Min. Sci. Press*, **111**, 167 (1915).
[3] H. Salinger, *Min. Sci. Press*, **111**, 899 (1915).

the feed to the first cell. The ore is mainly chalcopyrite and gangue. It assays 0.70 per cent. copper. The concentrate assays 25 per cent. copper and the extraction is 70 per cent. The total cost including flotation royalty and the handling of old tailings to the mill by drag conveyor is 55 cts. per ton.

The Gold Hunter mill illustrates Coeur d'Alene practice on a complex ore.[1] The ore contains argentiferous galena, blende, pyrite, tetrahedrite, stibnite, siderite, barite and quartz, and is treated as follows:

1. Mine ore bin. By belt conveyor to (2).
2. Grizzly, 1½ in. Oversize to (3); undersize to (7).
3. One Blake breaker, 12 by 20 in. To (4).
4. One trommel, 1¾ in. Oversize to (5); undersize to (7).
5. Sorting belt. Waste picked out; residue to (6).
6. Comet breaker. To (7).
7. Belt conveyor to 300-ton mill bin. To (8).
8. One set of rolls, 12 by 36 in. To (9).
9. Bucket elevator to (10).
10. One trommel with 11-mm. holes. Oversize to (11); undersize to (13).
11. Two bull jigs. Concentrates to smelter; tailings dewatered to (12).
12. One set of rolls, 12 by 36 in. To (9).
13. One trommel with 7 and 9-mm. holes. Over 9-mm. to (18); through 9 on 7-mm. to (19); through 7-mm. to (14).
14. One trommel with 3 and 5-mm. holes. Over 5-mm. to (20); through 5 on 3-mm. to (21); through 3-mm. to (15).
15. Two screens with 20-mesh screens. Oversize to (22); undersize to (16).
16. One drag classifier. Sand to (17); overflow to (34).
17. One Handy classifier with one spigot. Spigot to (23); overflow to (24).
18. Two Harz jigs, 3-compartment. Concentrates to smelter; tailings to (28).
19. Two jigs, 3-compartment. Products like (18).
20. Two jigs, 3-compartment. Products like (18).
21. Two jigs, 3-compartment. Products like (18).
22. Four jigs, 2-compartment. Products like (18).
23. One Wilfley table. Concentrates to smelter; tailings to (25).
24. Three Wilfley tables. Products like (23).
25. Two bins. By drag feeder to (26).
26. One 5 by 14-ft. tube mill. By elevator to (27).
27. One drag classifier. Sand to (25); slime to (35).
28. Two bins. By two drag feeders to (29).
29. Two tube mills, 6 by 14 ft. By elevator to (30).
30. Two screens with 20-mesh holes. Oversize to (28); undersize to (31).
31. Two drag classifiers. Sand to (33); slime to (32).
32. One drag classifier. Sand to (35); slime to (34).
33. Eight Wilfley tables. Concentrates to smelter; tailings to (25).
34. Twelve 8-ft. Callow cones. Spigots to (35); overflow to waste.
35. Two Pachuca mixers for flotation. To (36).
36. Six roughing Callow cells in parallel. Froth to (37); tails to waste.
37. Three cleaning Callow cells in series. Froth by one centrifugal pump to (38); tailings by three centrifugal pumps to (35).

[1] *Eng. Min. Jour.*, **100**, 1044 (1915).

38. Two 8-ft. Callow cones. Spigots by centrifugal pump to (39); overflow to (26).

39. One 8-ft. Callow cone. Spigot to (40); overflow to (35).

40. Oliver filter delivering product with 8 per cent. moisture.

The mill treats 310 tons in 24 hr. and makes 35 tons of concentrates, half of which come from flotation. Flotation has raised the mill extraction from 50 or 60 per cent. up to 80 per cent. No tailings go to waste except through flotation. The ore assays 5 or 6 per cent. lead and the tails 0.6 to 0.8 per cent. The feed to flotation averages 4 to 5 per cent. and it is practically all finer than 65-mesh.

Southeast Missouri lead-mill practice is pretty well standardized. The ore averaging about 4 per cent. lead is crushed in breakers and rolls to about 10 mm. Trommels or classifiers divide the ore at about 1.5 or 2.5 mm., the material above this size going to Hancock jigs and finer to Butchart tables. Jigs and tables make concentrates, middlings and tailings. Tailings are waste. Jig middlings are re-crushed in rolls and sent back to the same jig or to a second similar jig making similar products. Table middlings are usually re-treated without crushing, although there is a tendency to re-crush the coarsest table middlings. All slimes and muddy water are settled in settling tanks, Callow cones and Dorr thickeners and go straight to flotation or first over riffle tables. The flotation process gives an extraction of about 80 per cent. on slimes averaging 2.5 to 4 per cent. lead. About 12 to 15 per cent. of the total mill feed goes to flotation. Flotation adds about 15 per cent. to the mill recovery, bringing the total extraction up to 80 or 85 per cent. A few Harz jigs and vanners are in use in one or two of the mills.

Joplin milling practice at its best has been shown by careful test to extract about 67 per cent. of the zinc and 90 per cent. of the lead. The losses come in the coarse jig tailings and in the slimes. Jigs save no mineral finer than 35-mesh and tables no mineral finer than 150- or 200-mesh. It is a question whether re-crushing of the coarse tailings will pay. Additional saving can be made from slimes by tables and flotation where the size of the mills will warrant the installation of a flotation plant.

Tin dressing at Llallagua, Bolivia, has been described by D. Copeland and S. E. Hollister.[1]

The Timber Butte mill, described last year in MINERAL INDUSTRY, has been written up in very full detail by T. Simons.[2]

Lake Superior copper milling practice has been discussed by T. T.

[1] *Eng. Min. Jour.*, **100**, 461, 513, 555 (1915); *Metall und Erz*, **12**, 489 (1915).

[2] *Bull. Amer. Inst. Min. Eng.*, **102**, June, 1915, p. 1295; *Min. Eng. World*, **42**, 329, 1030 (1915); *Met. Chem. Eng.*, **13**, 188, 447 (1915); *Mex. Min. Jour.*, **20**, 279 (1915); *Metall und Erz*, **12**, 118 (1915); *Eng. Min. Jour.*, **99**, 991 (1915).

Read,[1] covering the operations of coarse crushing, stamping, concentrating and re-grinding of tailings with special reference to the Calumet & Hecla mill.

Milling practice on lead-zinc ores at Broken Hill, Australia, is the subject of a good article which covers the coarse crushing by breakers, fine crushing by rolls, jigging, classifying, tabling and re-grinding in pans and tube mills.[2]

In the new Gennamari lead mill in Sardinia, described by C. A. Wright,[3] the mill extraction has been raised from 60 per cent. up to 80 per cent. by using larger Harz jigs, by replacing the fine jigs with tables, and by installing a slime plant containing spitzkasten, slime tables and vanners.

The elaborate Clausthal mill for treating zinc-lead ores has been described by E. M. Heriot[4] including jigs, tables and slime tables and the Murex magnetic flotation process.

Preparation of Coal

The bibliography at the end of this article gives a good idea of progress in the cleaning of coal. Of special interest in anthracite is the new breaker of the Markle Co. at Hazelton, Pa. This has a steel frame and iron sides and roof, but wooden floors, bins, etc. It is not fire-proof, but is a step in that direction. Steel frame costs 60 per cent. more than wood.

In bituminous work a plunger jig plant has been installed by the Tennessee Coal, Iron and Railroad Co., and a Stewart jig plant by the Ayrshire Coal Co. at Oakland City, Ind. The product of this jig is screened into four sizes between 2¼ in. and 0 for the market. A spiral separator plant has been built in Illinois. The Richards pulsator jig is finding favor in coal washing and the Wilfley table is made in a special design for coal.

For drying washed coal the Wendell continuous centrifugal drier is doing successful work in Alabama.

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[3] *Eng. Min. Jour.,* **100,** 794 (1915).
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CONCENTRATION BY FLOTATION

By M. W. von Bernewitz

Introduction

In the nineties the gold and silver metallurgists had their time occupied in adapting the cyanide process to ores, for many years a chemical problem, and later on mechanical; during the past 2 years, especially in 1915, the copper, lead, and zinc metallurgists have been improving the extraction of these metals by flotation, generally regarded as a physical and mechanical process, in which chemistry, while of importance in nature of ores, plant solution, character of oils, and temperature, plays a minor part. It is significant that the well-known cyanide laboratories and testing works throughout the country are equipped with flotation apparatus. The increased interest, experimenting, and adoption of one of the many flotation systems last year was tremendous, and it is almost impossible to keep track of new installations. From Chickagof in Alaska to Braden in Chile, Sulitjelma in Norway to Mt. Lyell in Tasmania, and Suan in Korea to Mascot, Tenn., in the United States, many metallurgists have been busy testing ores, installing plants, and recovering metals by flotation. The process has not been restricted to the base metals; as will be seen later on in these notes, the precious-metal producers are keenly alive to its help in cyanidation. Litigation over basic patents occupied the courts, as it has more or less for several years, which is most unfortunate. A veil of secrecy and mystery, which is loudly condemned, surrounds the work of some investigators who are benefiting by certain processes. In spite of this, the Patent Office, whose system has been much criticised, and many suggestions have lately been made for improvements in its system, issued a number of patents for new systems of flotation by experimenters at many mines. The *Mining and Engineering Review* of Melbourne, Australia, questions whether in that country, where the application of flotation on a large scale was started, the slow extension of the process is not due to the status of the patents and those controlling them. Up to 1914 little had been published in the technical press regarding flotation, but last year the matter became so important that valuable articles and discussions appeared. The second edition of T. J. Hoover's "Concentrating by Flotation" appeared late in 1914, and had been the only textbook on the subject. This was supplemented and greatly improved by

"The Flotation Process" of T. A. Rickard, in March, 1916, containing much valuable data compiled from a flotation publicity campaign started by him in the *Mining and Scientific Press* during 1915.

The opening chapter of this new work consists of a comprehensive paper by Mr. Rickard presented to the Canadian Mining Institute at the March, 1916, meeting, and published in the *Press* during that month. This paper, though the latest of all in chronological order, is intended to act as a general introduction to the subject, and it answers this purpose admirably, discussing in turn the physics of the process, the various methods and devices for applying it, the history of its inception and development as illustrated by the various patents secured to protect it,

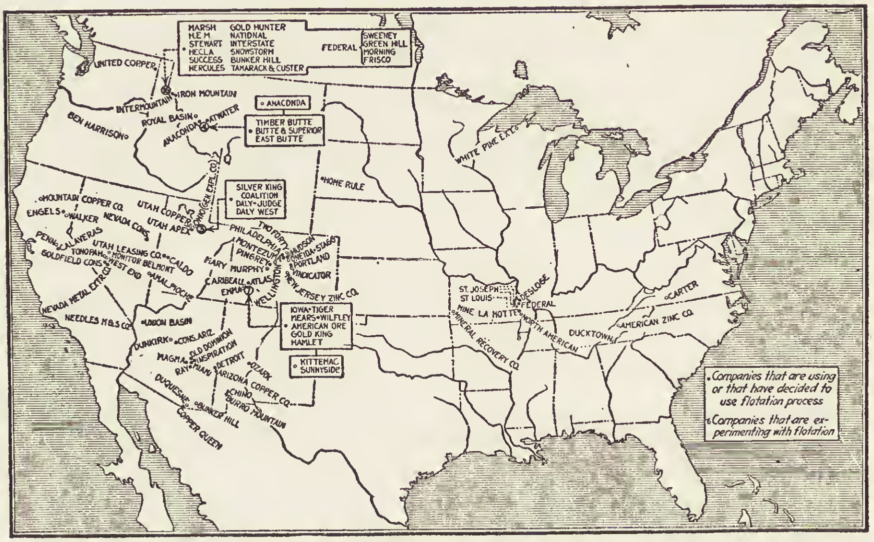

FIG. 1.—Companies using or experimenting with flotation in the United States.

and commenting on the psychological factors involved in its career. The two articles by Mr. Rickard entitled "What is Flotation?" were designed to set forth in simple language for the benefit of the unitiated the somewhat meager information at that time available. The *Engineering and Mining Journal* and *Metallurgical and Chemical Engineering* also published valuable papers, so it will be seen that history is in the making.

Interest now surrounds progress made in the United States, and we find the following widespread work being done, better understood by a reference to the accompanying map:[1]

[1] *Eng. Min. Jour.*, Jan. 8, 1916.

Copper ore at Chickagof, Alaska; Arizona Copper, Consolidated Arizona, Copper Queen, Inspiration, Magma, Miami, Old Dominion, and Ray Consolidated in Arizona; Calaveras, Engels, Mountain Copper, Needles, Penn, and Walker in California; National in Idaho; Calumet & Hecla and White Pine in Michigan; Anaconda and East Butte in Montana; Nevada Consolidated in Nevada; Burro Mountain and Chino in New Mexico; Tennessee Copper in Tennessee; Ohio, Utah Apex, and Utah Copper in Utah; and United Copper in Washington. Several important copper producers in British Columbia are to increase their yields by flotation. Gold and silver at the Bunker Hill in Arizona; Royal mine in California; Portland and Vindicator at Cripple Creek, and several complex precious and base-metal mines in Colorado; and the gold-copper ores of the Goldfield district of Nevada. Lead and zinc at the Bunker Hill and Sullivan, Federal group, Hecla, Hercules, Marsh, Success, Stewart, and Tamarack & Custer in the Coeur d'Alene, Idaho; Doe Run, Federal, St. Joseph, and others at Flat River, Mo. (lead only); Amalgamated Pioche, Nev.; and Daly-Judge, Daly West, and Silver King Coalition, Park City, Utah. Zinc at the Golconda, Ariz.; Joplin, Mo. (experimenting); Anaconda, Butte & Superior, and Elm Orlu in Montana; Ozark in New Mexico; and Mascot in Tennessee. In Colorado a number of companies producing a complex copper-lead-zinc-silver ore, such as the American, Atlas, Iowa-Tiger, Mary Murphy, and Wellington, are increasing their production. In Sonora, Mex., a silver-gold-copper-lead-zinc producer finds the process of advantage. The great silver companies at Cobalt, Ont., are also studying flotation. The past year witnessed many interesting investigations and installations, culminating in the magnificent 15,000-ton daily capacity mill at the Inspiration, Ariz., which was in full operation in March, 1916. At the present time a total of 55,000 tons of ore daily is being treated in the United States and this quantity is rapidly increasing.

It must not be considered that flotation will be a cure-all for rebellious ores, nor the only metallurgical process for any particular ore, but as an auxiliary it is certainly going to fill a long-needed deficiency. So far, only sulphide minerals can be successfully floated, but there is promise from the oxide ores, judging by recent work. This point, the acidity or alkalinity of plant solutions, and character of oils, are really the only chemical phases of flotation. There are instances where some sulphide ores can be treated only by flotation. Others are best crushed, concentrated first by water and then by oil, the finer portion of the pulp being reserved for the latter.

Litigation

The most important dispute was that of the Minerals Separation *vs.* the Miami Copper Co., heard at Wilmington, Del. A decision was expected toward the end of 1915, but up to April, 1916, it had not been announced. It is probable that judgment was deferred until the final decision of the Supreme Court of the United States in the Minerals Separation *vs.* Hyde suit was given. In this suit some extremely interesting arguments were advanced showing that the Court took an intelligent interest in the process. A portion of the legal version was published in the *Mining and Scientific Press* of Oct. 16 and Nov. 6, 1915. The phenomena of surface tension and bubbles was discussed, also the basic patents.[1]

The decision in the Hyde case, now before the Supreme Court, has been postponed for unavoidable reasons until next October or November. In the Miami case the Judge is carefully examining the voluminous evidence, but may give a verdict at an early date.

Theories

During the latter part of 1915 and early in 1916, a series of articles in the *Mining and Scientific Press* by T. A. Rickard, C. T. Durell, O. C. Ralston, Will H. Coghill, W. A. Scott, J. A. Block, Thomas M. Bains, Jr., Dudley H. Norris, and F. A. Fahrenwald, advanced and discussed various theories of flotation. These were generally highly technical, the electrical theory causing considerable comment, somewhat combated by Mr. Fahrenwald. A large proportion of the articles consisted of attempts to formulate a workable theory to account for the phenomena displayed, and though this aspect of the matter may seem to some readers of less practical importance than that of the commercial results of the process and the *modus operandi* of the tests and working plants, yet those who are occupying themselves in the business of theoretical research are performing a very real and practical service for the industry, because up to the present experimental work in the application of the process has been almost entirely empirical or, in other words, has been conducted on the "hit or miss" method. It is obvious that if definite rules could be formulated that would determine beforehand, if only approximately,

[1] While never having been actually employed on flotation work, I have been a quiet student of all that has been going on since the commercial development of the process of Australians. In 1906 I visited Broken Hill, New South Wales, and there saw the Potter-Delprat process treating 1000 tons of valuable lead-silver-zinc tailings per day. At that time the Zinc Corporation was using the Elmore vacuum system, but was experimenting extensively with other processes; the Sulphide Corporation was developing its process; and litigation was in the air. Later on I watched the testing of the sulpho-telluride gold ores of Kalgoorlie, Western Australia, and various ores at laboratories in San Francisco. The ultimate result of flotation on American base and possibly precious-metal ores will be much higher recoveries, lower costs, largely increased metal production, and that desirable end, conservation of resources by these higher recoveries instead of a commercial article going to waste. (The writer.)

the method and conditions necessary for any given class of ore, progress on the commercial side would be much more rapid, according to E. M. Hamilton of San Francisco, who reviewed these articles.

Mr. Durell propounds a theory that gas bubbles mechanically held in a pulp are powerless to float mineral products, and that to be effective, the gas must go into solution in the liquor under such conditions that it is liberated, or brought into being as a bubble, at the surface of the particle it is destined to float. This is a possible hypothesis, but the arguments he adduces seem hardly conclusive, and evidence to the contrary is cited from the case of Minerals Separation Ltd. *vs* Miami Copper Co., in a communication by James A. Block. He is also committed to a theory that gases occluded in the mineral particles play a vital part in the physics of flotation, a view that is strongly contested by Mr. Ralston, who offers two alternative hypotheses, one based on the action of interfacial tensions, and the other on the electrical charges carried by suspended particles. This electrical theory of flotation is further advocated by Thomas M. Bains, Jr., and discussed in more detail in a paper by F. A. Fahrenwald. The phenomena and laws of surface tension are set forth in two instructive articles by Will H. Coghill and Dudley H. Norris has a stimulating dissertation on "Molecular Forces in Flotation."

"Universal Flotation Theory" is the title of a paper by C. Terry Durell[1] in which he considers that it seems incredible that every one of the many flotation processes are satisfactorily explained by an all-embracing theory. How can the theory of film flotation be identical with that of froth flotation? How is the theory of the Cattermole the same as that of the Callow? The essential elements of flotation can be arrived at in two ways: (1) investigation of conditions under which different minerals float, and (2) of all different processes. After scanning the results of Kenneth A. Mickle in Australia, those of Swinburne and Rudorf, surface-tension flotation, bulk-oil flotation, froth flotation (including the Delprat, Elmore, Minerals Separation, De Bavay, Callow. and liquid-jet systems) electrically charged bubbles, selective and preferential flotation, osmosis, persistency of bubbles for froth, oils and frothers, Mr. Durell concludes by saying that "most oils aid flotation in three ways: by (1) increasing surface-tension of the oil-film with the additional force of surface-tension of the water-film; (2) decreasing adhesive force of the water for metallic particles by forming films around them; and (3) increasing cohesive force of metallic particles for each other by means of the oil-film. Thus it is seen that although oil is a great aid, there can be no universal theory for flotation which considers

[1] *Colo. School of Mines Mag.*, Feb., 1916.

oil necessary. By this method of elimination, it is shown that all processes and kinds of flotation can be satisfactorily explained by gas occlusion, and that the bubbles for froth formation are from nascent gas."

"Liquid Jets: A Study of a Phenomenon of Importance in Flotation," is the title of an article by C. Terry Durell,[1] who considers that the whole subject of flotation depends on gas absorption. The mineral to be saved as a concentrate must have occluded sufficient gas to prevent its being wetted by the flotation liquid; once wetted with this, its tendency is to sink, as there can be no surface-tension effect tending to float it. The flotation liquid may be assumed in all cases to be water. Only flotation of submerged particles was considered by the author. If a particle is to be floated by means of minute bubbles, these must be attached to the particle; or, if it is to be floated by means of a froth, the particle must be attached to a bubble. As air is readily soluble in water, and since it is occluded by most solids, it is the cheapest and most preferable gas for flotation. Air is soluble in oil, which is practically insoluble in water, therefore gas can be much easier attached to oiled-mineral particles. The thinnest possible film of oil is all that is needed. By adding an acid or alkali to the water to form an electrolyte, an ionized condition is produced, creating a selective action of flotation due to occlusive power of at least some of the minerals being effected. Flotation depends entirely on dissolving air in preferably an electrolyte as well as in the ore and then the expulsion of this air. The simplest way to supersaturate water with air at atmospheric pressure is to beat it in with paddles or stirrers, as in the Minerals Separation machine. The injection of liquid jets into a gas is worthy of investigation. This may be done by injecting them vertically upward or downward, or at an angle. A jet of liquid turned into a gas does not merely slide through that gas, or a cylinder of that gas, but carries the "gas cylinder" along with it. When a liquid is entirely saturated with a gas brought in with a jet, supersaturation has the effect of producing nascent gas, which collects in the form of bubbles. This fact is taken advantage of for flotation. The hydraulic compression of air[2] is an instance of a liquid jet downward through a gas, namely, air.

"Air-froth flotation" is the legal version of W. A. Scott[3] on the technology of flotation, in his address as counsel for defendants in the suit of Minerals Separation *vs.* Miami Copper Co. The argument is extremely interesting, and shows an intelligent understanding of the

[1] *Met. Chem. Eng.*, Oct. 15, 1915.
[2] *Min. Sci. Press*, Aug. 14, 1915.
[3] *Min. Sci. Press*, Oct. 16, 1915.

process. Counsels for the complainant, H. D. Williams and W. H. Kenyon, also gave their version of the dispute.[1]

The article of Dudley H. Norris,[2] "Flotation—A Paradox," discusses flotation patents, including his own, and their respective claims and values. The author writes in a facetious strain, and was not partial to the Minerals Separation Co.

Recent Progress

Progress of flotation in 1915 is briefly covered by Herbert A. Megrew,[3] from whose notes the accompanying map (Fig. 1) is taken. He considers that continued litigation over basic patents hampered investigation, but the spread of the process was so rapid that by sheer weight of merit some of the important data was made public. Some articles in the technical press contained useful information; a good many did not. Probably the most important article of the year was that by J. M. Callow.[4] As an auxiliary metallurgical process, flotation seems to be succeeding in filling a niche that has been left completely vacant up to this time. There is great danger of the universal adoption of the process reacting to its disadvantage through failure when the ratio of concentration is low. It is considered better practice to begin with gravity concentration and finish with flotation; when concentration ratio is high, make flotation the principal process, with gravity concentration an auxiliary. It may be said that any kind of ore in which the mineral occurs in sulphide form is susceptible to flotation. An important feature of the past year's development is the indication that flotation is going to replace the cyanide process to a great extent, particularly at mines where the silver is principally in the sulphide form, and low grade. Cyanidation of flotation concentrate will be a problem. Mr. Megraw discusses in an interesting manner the effect of varying details on flotation, and applications of the process, that is, how certain ores will give an increased extraction. No theories advanced on the process are proved, and a definite one will be of great assistance in experimental work.

"Flotation: Its Progress and its Effect upon Mill Design" is the title of a rather interesting and well-illustrated article by C. A. Tupper.[5] He considers that during 1915 the subject has received a great deal of irresponsible comment, and the practical millman could glean little of value from all the material published. The author quoted "a leading authority" who said among other things that "The flotation process is in a chaotic state, and while a great deal of money is being spent on

1 *Min. Sci. Press*, Nov. 6, 1915.
2 *Min. Sci. Press*, Dec. 25, 1915.
3 *Eng. Min. Jour.*, Jan. 8, 1916.
4 *Bull. Amer. Inst. Min. Eng.*, Dec., 1915.
5 *Min. Eng. World*, Jan. 1, 1916.

experiments, no one is publishing results. Such a condition will continue until the litigation now pending is disposed of. . . . . . There is no standard practice. . . . . . Each ore requires a special treatment. . . . . . Manufacturers of oils have not been able to standardize their product. . . . . . The flotation machine with direct-connected drive is much superior to the other type. . . . . . Several millmen have developed what appears to be an improvement on the Janney and Minerals Separation machines, but if the Minerals Separations wins the suit none of these can be used. . . . . . Until the broad question of the free or restricted use of the process has been adjudicated, development of flotation machines will be curtailed. . . . . ."

Mr. Tupper then briefly reviews what is being done in the various States. The Butte & Superior Copper Co., which, by the way, is a zinc, lead, and silver producer, and has changed its name, has attracted great attention by its results, and, of course, through the litigation with the Minerals Separation Co. The flotation plant consists of three units, each having two emulsifying agitators. After the pulp passes through these it goes to five Janney flotation machines, working in parallel. Tailing from these join and go to 10 machines in series. Concentrate from the five multiple (or parallel) machines, and that from four or five of the series machines, are united with those of the other two sections, and elevated to a storage-tank. From here the rougher concentrate is distributed to five flotation machines in parallel to operate as a cleaner unit. Concentrate from this goes to five machines in parallel, a re-cleaner unit. Concentrate from the last five or six cells of the series machines of the rougher units, with tailing from the cleaner and re-cleaner units, is returned to the flotation system as middling for re-treatment. The complete plant consists of 6 emulsifying cells and 55 flotation machines. Reagents used are sulphuric acid, pine-oil, and copper sulphate, the operation being performed in cold solution. Dorr thickeners and Kelly presses are used to prepare the final product for shipment.

The great 14,000-ton flotation plant at Anaconda is briefly described. This will be given further consideration in another abstract, as will also the Elm Orlu plant.

At the East Butte copper mine an 800-ton flotation plant has been started recently. It treats second-class ore and old tailing. A Janney machine of 400-ton capacity is part of the flotation equipment.

Progress in flotation has been excellent in Arizona. The 15,000-ton mill at the Inspiration copper mine is in full swing. Kennedy gyratories, Symons disc-crushers, Marcy ball mills produce a 48-mesh feed for the flotation machines. Deister concentrators are also used.

Other mills where flotation is in successful operation or in the experimental stage are the Consolidated Arizona, Ray Consolidated, Magma Copper, Miami Copper, Copper Queen, and Arizona Copper. These are briefly touched on by Mr. Tupper.

In Colorado, a large number of companies use flotation, and the general practice is summarized as follows by a Denver engineer for Mr. Tupper:

"Run-of-mine ore passes over 1½ to 2-in. grizzly, oversize to Blake or gyratory-crusher, undersize to storage-bin with crushed product, ball mills reducing ½–2-in. ore to 12–40-mesh, mechanical or hydraulic classification for elimination of slime, coarse product from classifier to tube mills for final reduction to pulp from 40–200-mesh, depending on the system, and then flotation."

Several plants use flotation in Utah, treating copper, lead, and zinc ores. A great deal of experimental work in this State has centered about the General Engineering Co.'s plant at Salt Lake City, where the Callow system is operated.

Rapid progress was made in flotation at the lead, zinc, and copper mines of the Coeur d'Alene, Idaho, where the output of the metals has been largely increased by the processes in use.

Mr. Tupper briefly covers Nevada, New Mexico, Washington, Michigan, California, and British Columbia, concluding with a practical summary of the process.

"Recent Progress in Flotation" is by O. C. Ralston and F. Cameron,[1] who consider that the exchange of ideas is hindered by litigation, which is briefly but interestingly reviewed. It seems as if much of the older concentrating machinery will be displaced by flotation apparatus. As one instance, one copper company has decided to displace all concentrating machinery save rougher-tables, and then re-grind the tailing from these for flotation. Another development in American practice is the cleaning of both flotation concentrate and tailing; also re-cleaners for further treatment of concentrate from the froth cleaners when using the Callow system. Breaking-up and settling froth has been troublesome. Oliver and Kelly filters reduce moisture in concentrate to about 10 per cent. Preferential flotation of mixed sulphides is a field for much investigation. The subject of oils is all-important. An oil suitable for treatment of certain minerals will not concentrate these in all cases. Acid does not always help treatment, although the presence of any electrolyte seems to have a marked effect on flotation. While heated mill water is advantageous in some cases, the effect of temperature is not decided. Improvements in mechanical agitation are being made, but toward rigid practice, while in pneumatic-flotation machinery, modifications tend

[1] *Eng. Min. Jour.*, May 29, 1915.

toward the greatest freedom of design possible. The Field's electric-flotation process was an innovation, in which flotation is to be accomplished by hydrogen bubbles developed by electrolysis of the solution mixed with the pulp. Careful work is under way to float oxide ores. A promising method is of sulphidizing oxide minerals of copper and lead by a soluble sulphide, then floating the artificial sulphides formed.

Processes

"Notes on Flotation," by J. M. Callow,[1] was the modest title of probably the most interesting and valuable of the articles published during 1915. It was reprinted in all the leading technical journals. A historical sketch covers the disclosures of the selective action of oil for lustrous minerals by Haynes in 1860, Carrie Everson in 1885, the bulk-oil process of the Elmore brothers, Potter and Delprat acid-gas process in 1902, oil and gas by Froment in 1902, Cattermole in 1902, Sulman, Picard, and Ballot soon after, Macquisten surface-tension system in 1904, and Hyde in 1912.

Discussing pneumatic flotation, Mr. Callow says that early in 1909 he did a great deal of work on the Macquisten process at the Morning mine, Mullan, Idaho. A lot of experimenting led to the present air system of flotation. The first application of this was at the National copper mine nearby, in April, 1914, and was a success. Since that date, the method has been adopted by nearly all the other mills in the Coeur d'Alene treating lead and lead-zinc ores, notably the Gold Hunter, Morning, Hercules, Bunker Hill & Sullivan, Caledonia, Last Chance, Hecla, Standard, etc., a total of about 50 cells, treating from 1500 to 2000 tons of slime and fine sand per day. The same method also has since been adopted by the Inspiration, Arizona, Anaconda, Magma, and other copper companies, and by the Silver King, Daly-Judge, Duquesne, and El Rayo mining companies, on lead, zinc, and other ores, making a total of some 680 cells in operation or in the course of erection, having a combined capacity of 25,000 to 28,000 tons per day.

The accompanying illustration is almost self-explanatory. The rougher separatory-cell *B* is a tank 9 ft. long, and 24 in. wide, with a bottom inclined at from 3 to 4 in. of fall per ft.; it is 20 in. at the shallow end and 45 in. deep at the deepest end. It may be built of either steel or wood, preferably wood. The bottom of the tank consists of a porous medium made of four thicknesses of loosely woven canvas-twill, properly supported by a backing of perforated metal to prevent bulging when under air-pressure. Through this porous medium compressed air is forced by the blower *E*. Porous brick or any other ceramic material may be used to

[1] *Bull. Amer. Inst. Min. Eng.*, Dec., 1915.

ensure the necessary fine subdivision of the air. This space underneath this porous medium or bottom is subdivided into eight compartments, each connected by an individual pipe and valve with the main air-pipe *F*. By this means the air-pressure to each compartment can be regulated (by throttling the valve) to correspond with the varying hydraulic head within the tank, so as to discharge a uniform amount or air throughout the length of the bottom and maintain a uniform aeration of the contents. A pressure of from 4 to 5 lb. is generally used and each square foot of porous medium requires from 8 to 10 cu. ft. of free air per min. Each

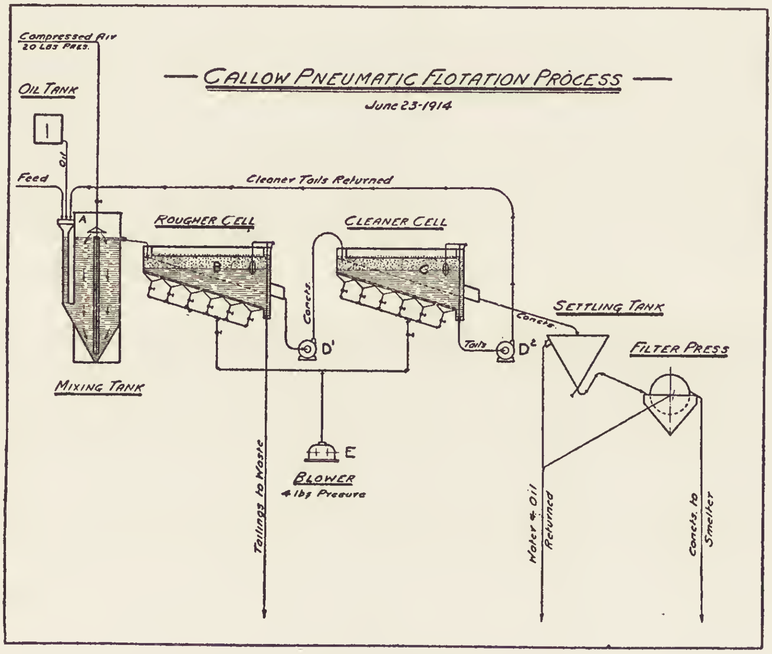

FIG. 2.—Callow cell.

longitudinal edge of the tank is provided with a lip and an overflow gutter for the reception of the froth to be discharged. The lower end of the tank is furnished with a spigot-discharge fitted with a plug-valve, operated by a float, for the purpose of maintaining a uniform water-level within the tank, thus in turn securing a uniform and constant discharge of froth under all the varying conditions of feed incident to practical milling operations. The water-level, may, of course, be varied; but it is usually maintained at about 10 to 12 in. below the level of the overflow-lips. The tailing is discharged through the spigot and the frothy concentrate is conveyed by means of the side-gutters to the pump *D*-1, thence to the cleaner-separatory cells marked *C*. This cleaner-cell is a machine of the same construction as the rougher; in operation, however, it is usually run with a lower air-pressure; the tailing from the cleaner is pumped by *D*-2 back to the original feed, and thus a closed circuit is maintained on this portion of the feed. The concentrate from the cleaner is the shipping or finished product. Pump *D*-1 can well be eliminated by setting the cleaner at a lower elevation and conveying the rougher-froth to it by gravity. Usually one cleaner serves four roughers. The machine may be run either in parallel or in series without any sacrifice in capacity for a given number of cells. At the Inspiration, the original feed goes to 12 primary roughers, the tailings from which are classified into sand and slime, the sand going to tables and the slime being returned to 12 secondary roughers. The concentrates from both the primary and secondary roughers go to four cleaners, and the cleaner-tailing back into circuit. This section, of 800 tons daily capacity, gives 33.3 tons per roughing-cell.

The froth is generated as the result of injecting the finely divided air into the bottom of the already emulsified pulp; it continues to form and to overflow so long as it is furnished with pulp of the proper consistence properly mixed with the right quantity and kind of oil or frothing agent. Measured from the water-level within the tank, the froth produced may be from 14 to 16 in. in depth or thickness, and according to the character of ore, kind and quantity of oil introduced, will be more or less voluminous, coarse- or fine-grained, dry or watery, all of these conditions being adjusted by the regulation of the kind or quantity of oil and the quantity of air injected.

In the case of some ores, rich in sulphides, when a comparatively low-grade concentrate will suffice, the "cleaner" may not be necessary, but on low-grade ores having a high ratio of concentration and demanding a concentrate of maximum purity, a cleaner is desirable.

The pulp to be treated may be of varying density, from 2½ : 1 water and ore, up to 5 or 6 : 1; for a mixture of sand and slime the former ratio is preferable, but for a pure slime mixture (—220-mesh) the larger proportion of water is allowable. The particular density is not a matter of so much importance as that the supply of pulp be uniform in density.

A normal capacity per standard roughing-cell is 50 tons per 24 hr. This, of course, will vary with the nature of the ore.

The oils used may be broadly divided into "frothers" and "collectors." The pine-oils are good frothers; coal-tar and its various subdivisions are good collectors. On some ores crude pine-tar will in itself combine both the properties of frothing and collecting. On others, this may have to be enriched by the addition of some one of its more volatile constituents, such as refined pine-oil, turpentine, or wood-creosote.

Generally speaking, the coal-tar products are poor frothers; to get a sufficient volume of froth to insure a high recovery, it is often necessary to add refined or crude pine-oil, creosote, etc. At the Inspiration, for instance, the mixture is 80 per cent. crude coal-tar, 20 per cent. coal-tar creosote; at another plant on similar ore 45 per cent. El Paso coal-tar, 40 per cent. coal-tar creosote, 10 per cent. cresol, and 5 per cent. pine-oil. At the Daly-Judge is used 40 per cent. crude coal-tar, 40 per cent. creosote, 20 per cent. pine-oil. In the Coeur d'Alene on zinc ore straight wood-creosote is used; on the National Copper ore plain turpentine will work, but pine-oil is better. At the Inspiration is used from 1½ to 2 lb. of the mixture per ton of ore; at the Daly-Judge, 1 to 1½ lb.; and at the National 0.3 lb. oil is sufficient. The proper kind or kinds of oil and the quantity requisite can only be determined at present by tentative experiment; so far no scientific short-cut is known.

The nature of the froth made by the pneumatic method has the distinctive characteristic of being unstable or ephemeral, that is, it quickly dies when removed from the action of the injected air. The bubbles composing the froth, being generated under a hydraulic pressure varying from 15 to 40 in., on rising above the water and to the froth-level, burst by reason of the lower surrounding atmospheric pressure. On bursting, they release the mineral attached to them, but this in turn is caught up by those bubbles immediately following behind. The instability or stability of the bubbles will depend, to some extent, upon the oil used and the nature of the gangue. In treating 500 tons of copper ore daily, the National Co. used a total of 35 hp. for flotation; and another plant treating 2400 tons required 210 hp. The oil-mixtures generally in use will cost from 1.25 cts. up to 3 cts. per lb., depending on the proportion of cresol and other high-priced oils used, but 1½ cts. per lb. will be a safe average on most ores. A consumption of 1 to 1½ lb. per ton, or from 1.25 cts. to 4.5 cts. per ton of feed, say 2½ cts. would be a safe average. The labor, of course, will vary with the size of the plant. At one plant consisting of 60 cells, two men per shift operate the entire plant, equivalent to a cost of 1¼ cts. per ton. One man per shift on a 250-ton plant will mean a cost of 5.4 cts. per ton in maintenance. Assuming a life of 3 months per blanket and 50 tons per cell, and an allowance for repairs to blowers, motors, pumps, etc., ½ ct. per ton is a liberal estimate.

Power at 1 ct. per kw.-hr. ($60 per hp.-year) and 2½ kw.-hr. per ton equals 2.5 cts. per ton of feed. At a 2000-ton plant, costs should not exceed 6.75 cts. per ton of feed. Actual figures from a 2000-ton mill are

6.1 cts., the flotation feed representing 60 per cent. of the crude-ore tonnage, or 3.5 cts. per ton of crude ore treated.

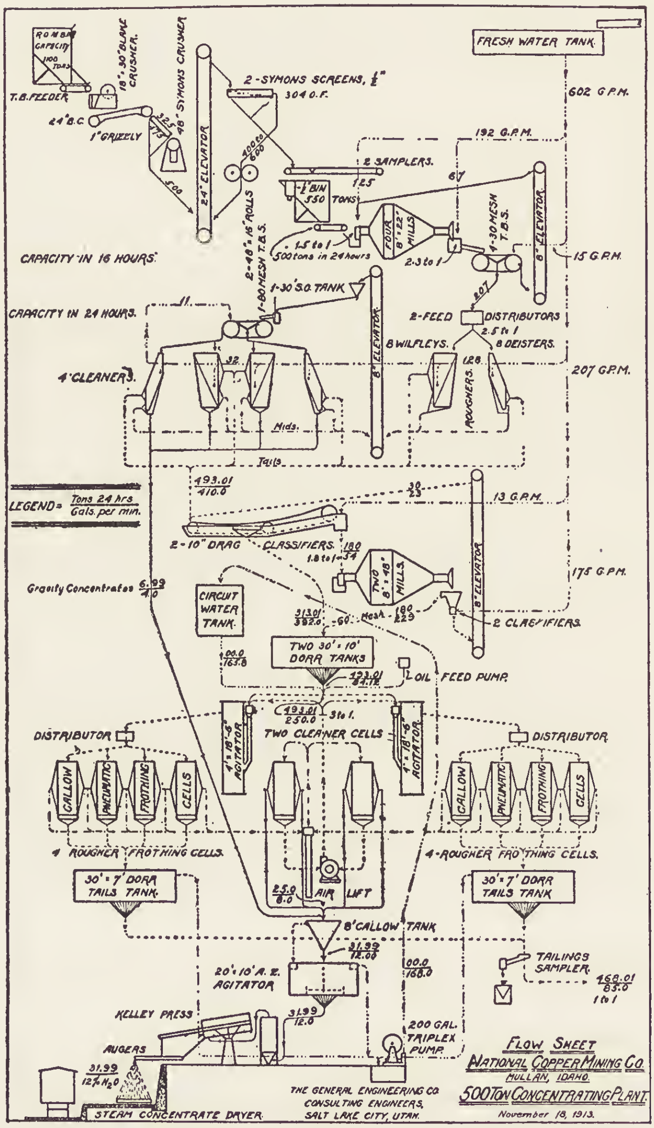

Fig. 3.—Flow sheet, National Copper Mining Co.

Mr. Callow considers no satisfactory explanation of flotation has been advanced. Under his direction a great deal of research has been done.

In considering the connection between flotation phenomena and the physical properties of the minerals concerned, there are two parallelisms to be studied: (1) It has been noticed for some time that the minerals which floated were not easily wetted by water, while those which were easily wetted did not tend to come up with the froth; and (2) there is a parallelism between certain electro-static characteristics and the flotation properties of ores. It seems possible that flotation is due to differences in polarity in the charges on the various particles of ore, and on the bubbles. Expressed briefly, flotation is an electro-static process.

Earlier in the year[1] Mr. Callow gave out probably the first notes of any importance on the flotation of copper ores, with a sketch of his pneumatic apparatus. He dwelt mostly on results at the National mine, Idaho, but gave useful hints and information on his machine, pulp density, power consumption, oils, and water. Regarding the last mentioned, owing to the supply being limited, the mill-water was re-used and accumulated acid, resulting in lower recovery of copper. Lime was added to make the water just neutral. Too alkaline a pulp made a large volume of froth, and did not improve the extraction.

The Callow pneumatic process of flotation is described[2] and illustrated, covering the roughing separatory-cell, construction, air required for a 500-ton plant, the cleaner separatory-cell, froth formation and character of froth pulp density, frothing and collecting oils, and classes used on different ores. This brief article conveys a lot of useful information.

Broken Hill, New South Wales, was the metallurgical center that developed flotation on a commercial scale, and one of the companies that did a lot of research was the Sulphide Corporation. In the November, 1913, *Bulletin* of the Australasian Institute of Mining Engineers, James Hebbard contributed a paper on flotation at the company's Central mine. This was reprinted in the *Mining and Scientific Press* of Sept. 4, 1915, as the information on early attempts at frothing, and discovery of the frothing process at Broken Hill at the same time as it was evolved by the now Minerals Separation, Ltd., in London, is very interesting.

Preferential flotation of galena and blende is successful at the Sulphide Corporation's plant, Broken Hill, New South Wales.[3] In this plant the Minerals Separation machines have been superseded by the Hebbard-Harvey underdrive machines. The capacity is about 4000 tons per week. The flotation plant receives tailing from the lead mill, where the largest part of the galena is separated. This tailing contains 4.2 per cent.

[1] *Min. Sci. Press*, May 29, 1915.
[2] Anon, *Met. Chem. Eng.*, Sept. 1, 1915.
[3] *Min. Eng. Rev.*, Melbourne, Australia.

lead and 18 per cent. zinc. The pulp is first agitated with eucalyptus oil, and the froth carries 57 per cent. lead. The residue assays 3 per cent. lead and 18.5 per cent. zinc. In the next flotation treatment oil and acid are used, and the concentrate assays 6 per cent. lead and 47.5 per cent. zinc. The final tailing assays 1 per cent. lead and 2 per cent. zinc. The process is conducted in the cold and effects the recovery of an additional 15 per cent. lead and silver compared with the process previously in use. Another important factor in this separation is that the new process may permit the fine tabling in the lead mill to be discontinued. Rhodonite forms the principal obstacle to successful tabling, as its specific gravity is between that of galena and blende. Flotation, however, gets rid of rhodonite as well as of other gangue matter, and makes possible an easier separation of the two minerals in subsequent tabling operations. During the 6 months ended June 30, 1915, this company treated 197,180 tons of ore, yielding 36,849 tons of concentrate assaying 64.4 per cent. lead, 34.3 oz. silver, and 8.1 per cent. zinc, equal to a recovery of 77.8 per cent. lead and 51 per cent. silver. There was produced by flotation from all sources 61,247 tons of concentrate containing 46 per cent. zinc, 7.9 per cent. lead, and 16.1 oz. silver. The extraction by all processes was 90.6 per cent. silver, 93.7 per cent. lead, and 92.8 per cent. zinc, figures equal to anything in the world on such ore, probably on any ore. Prior to flotation early in the present century, the lead recovery was under 70 per cent.

Separation of mixed sulphides in flotation, that is, first one mineral and then another is of great importance, and has received a great deal of attention in Australia. The term used as "preferential" flotation, and as described by O. C. Ralston[1] is the removal of one of the ordinary selectively flotative minerals in the presence of another similar mineral. Thus, a mixture of galena and sphalerite can be floated "selectively" from a gangue of granite, limestone, etc., while galena may be floated "preferentially" from a mixture of galena and sphalerite. Patent literature gives the following list of processes for preferential flotation: Cattermole in 1904, Wentworth in 1909, Ramage in 1910, Horwood in 1912, Lyster, Bradford, and Nutter and Lavers in 1913, and Greenway and Lowry in 1914. The Horwood is a process that has been used considerably in Australia and attracted attention. It depends on the "deadening" of galena and pyrite in a short roast at 300 to 500° C., whereby the galena is coated with lead sulphate, and the pyrite with iron oxide, while the sphalerite is unaltered. This allows of a separation of the zinc from the lead-iron-silver product, and allows of their separate marketing. The process was described in detail by Allan D. Rain in

[1] *Min. Sci. Press*, June 26, 1915.

the July number of *Teniente Topics,* the monthly publication of the Braden Copper Co., Chile.

Preferential flotation for mixed sulphides occupies the attention of many investigators, and the patent process of Leslie Bradford,[1] aroused interest last year. The distinguishing feature of the method consists in treating ores or ore-products in a medium which wets zinc sulphide, and does not wet lead sulphide or pyrite, and therefore leaves the last-named sulphides floatable, while rendering the zinc sulphide temporarily immune to flotation. The lead is first floated, then the zinc.

Testing

Among the most valuable articles published recently are the two entitled "Testing Ores for the Flotation Process," by O. C. Ralston and Glenn L. Allen,[2] who are on the staff of the U. S. Bureau of Mines laboratory at Salt Lake City. The following machines and devices are described: Macquisten tube, Wood, Potter-Delprat, Janney, Lyster or Hoover, slide, separating funnel, Owen, Callow, and Case. On a given ore with any given flotation machine, points of importance are method of grinding, fineness of grinding, kind of frothing agent used, amount of frothing agent, acidity or alkalinity, temperature, necessity of preliminary agitation, and effect of addition-agents in flocculating gangue-slime. The writers explain in detail the laboratory testing of ores by the various methods and applications of flotation. This may be considered the latest and most reliable information published, and the student just beginning experimental work in the process will find it invaluable.

Testing machines for flotation are importance, and they should be designed for flexibility in the desired directions, there being so many influencing factors, according to Ralph W. Smith.[3] The test-machine should also be proportional to the one used on a large scale, for obvious reasons. A sketch explained the construction of a closed-circuit, single-cell, Minerals Separation type flotation testing machine.

The laboratory flotation test-machine (Case) of the Denver Fire Clay Co. was developed during 1915, and a brief description and photograph appeared in the leading technical papers.

Chemistry

An excellent article[4] on the "Effects of Soluble Components of Ore on Flotation," discusses the cumulative effect on the efficiency of the cir-

[1] *Aust. Min. Stand.*, July 22, 1915.
[2] *Min. Sci. Press*, Jan. 1 and 8, 1916.
[3] *Eng. Min. Jour.*, Sept. 4, 1915.
[4] Anon. *Min. Sci. Press*, Dec. 18, 1915,.

culating mill-water of soluble substances derived from the ore. Most of the facts given have been recognized for some time by practical workers, but have not hitherto been published. The tests were made on a silicified-rhyolite ore assaying 37 oz. silver, 0.15 oz. gold, 1 per cent. lead, 0.25 copper, and 1.5 per cent. zinc. When treated by flotation in fresh water, the tailing assayed 13 oz. silver and the concentrate 440 oz.; when the water was re-used on a second lot of ore the respective assays were 18 oz. and 240 oz.; and on a third lot, 27 oz. and 190 oz., showing that some extremely deleterious substances had been dissolved from the ore. Ferrous and copper sulphates were found to be the principal fouling agents. These may be corrected by the use of sulphuric acid, or quick-lime, caustic soda, or sodium carbonate for the former; and hydrogen sulphide or sodium sulphide in an alkaline solution for the latter.

The effect of alkalinity[1] in flotation may be tested in a separating funnel. When frothing in mill-water, the best alkalinity, both as regards extraction and grade of concentrate, is from 0.01 to 0.02 lb. lime per ton of water.

Oils

Pine-oil is probably the oil most extensively used in flotation.[2] As the supply is limited, and the oil is consumed in many manufactures, and the demands by flotation are increasing largely, there may be a shortage. This oil is obtained by the distillation of yellow pine in Georgia and Florida. Pine-tar oil could be used in the event of a scarcity of pine-oil, which is corroborated by F. E. Mariner.[3] Its manufacture by the steam and solvent, and destructive distillation processes was described by C. A. Lunn.[4]

Testing oils for flotation is an important part of all investigations, and a well-equipped laboratory is necessary, according to J. Coutts.[5] To test the oil (eucalyptus and resinous oils chiefly) samples of ore are crushed through 60-mesh. A standard oil sample is that which has been found to fully meet the requirements of the proposition, on which all future calculations are based and comparisons made. It may be stored in bottles ready for use. The testing of oils is done by comparing measured quantities (3 to 6 drops) of a standard oil, with a similar quantity of the oil under examination. One pound of ore is mixed with 4 lb. of water at standard temperature, acidulated with a definite quantity of sulphuric acid. Oil is then admitted, the mixture is agitated in a

[1] Anon, *Min. Sci. Press*, Jan. 8, 1916,.
[2] *Eng. Min. Jour.*, Editorial, Mar. 6, 1915.
[3] *Min. Sci. Press*, Mar. 11, 1916.
[4] *Eng. Min. Jour.*, Apr. 3, 1915.
[5] *Aust. Min. Stan.*, Apr. 8, 1915.

machine. The float is skimmed off, dried, weighed, and assayed. A calculation of the amount of oil per ton of ore is also made.

Oils used in flotation will always be a subject for investigation. In a general way,[1] it may be said that oils of mineral origin, such as coal-tar and fuel-oil, give better results on copper ores, while oils of vegetal origin, such as the turpenes, pinenes, wood-tars, etc., are better adapted for the treatment of zinc and lead ores. Of the coal-tar products cresylic and carbolic acids are the best known reagents. Different brands of the former behave in a marked different way. A method of analyzing cresylic acid is given. The author found widely different results on any particular ore with Californian, Mexican, and Texan fuel-oils. They are not selective like cresylic acid, but are strongly emulsive, giving body and mineral-carrying power to the relatively weak but more selective froths. They are also cheap. Oils derived from wood were considered briefly. In the author's opinion, the pneumatic-flotation processes constitute the most distinct advance of recent years.

Coal-tar, not usually a good flotation agent, serves as an excellent base for use with frothing oils, reducing the required quantity of the latter, according to William A. Mueller[2] of the Inspiration Consolidated Copper Co. A great many of the expensive oils now used could be reduced in quantity if combined with a large part of coal-tar, which costs 5 cts. per gal. Not all coal-tars are suitable for an ore, and some tars are probably useless for any ore. A number of tests were made on an ore containing 1.6 per cent. copper, most chalcocite, with some chalcopyrite, and 0.15 per cent. oxide. The silica content was 72 per cent., and alumina 20 per cent. Various tars (and pine-oil) 1:1 mixture, on the same ore, gave fairly high recoveries, although variable; pine-oil (0.025 per cent.) and tar (0.06 per cent.) of ore, gave the best results with constant quantity of pine-oil; and constant tar (0.03 per cent.) and pine-oil (0.050 per cent.) of ore, gave the highest recovery.

Copper

In discussing present tendencies in copper metallurgy, E. P. Mathewson[3] states that in ore-dressing the flotation process is finding a vast field in sulphide copper ores, particularly those in which the sulphide minerals are finely disseminated. Numerous processes and flotation machines are being placed on the market. Tailing as low as 0.08 per cent. copper has been produced in long runs. A year ago the concentration of slime by flotation was considered impossible; now this is done without any

[1] Anon, *Min. Sci. Press*, May 1, 1915.
[2] *Eng. Min. Jour.*, Oct. 9, 1915.
[3] *Met. Chem. Eng.*, Mar., 1915.

difficulty. The material for flotation seems to concentrate better in proportion to the fineness to which it is ground, in many mills 60-mesh material is the coarsest sent to the flotation machines. In an editorial

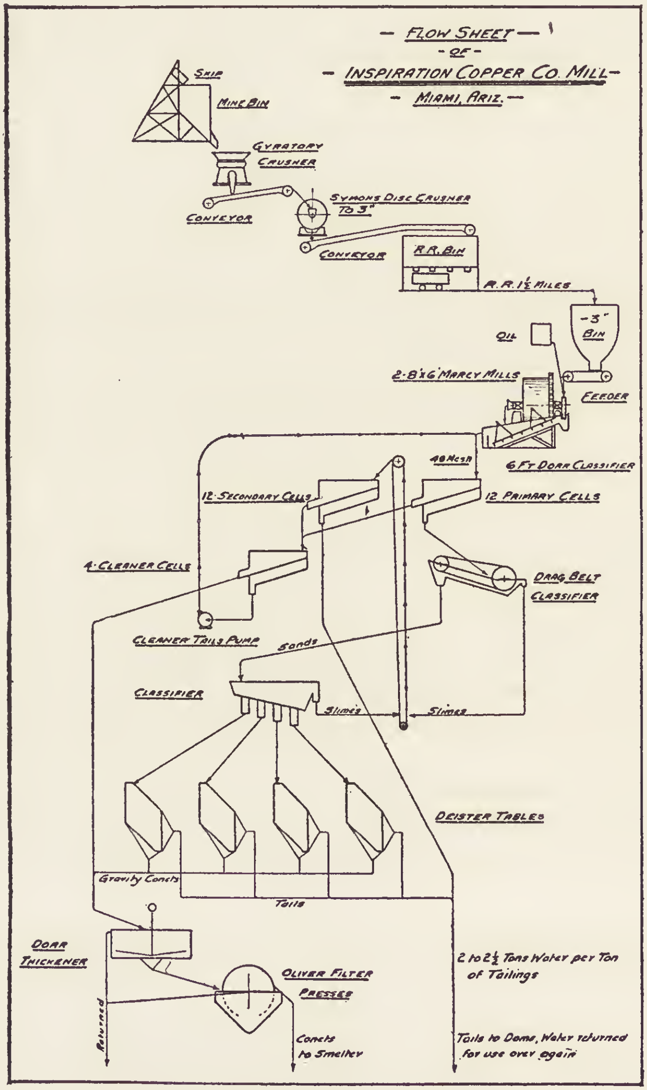

Fig. 4.—Flow sheet, Inspiration Copper Co.

note of the same date, it is considered that from its position as an intermediate process between gravity concentration and smelting, flotation exerts an influence in both directions. In ore-dressing it has proved the method par excellence for concentrating slime, hence this product is no longer a worry. A natural consequence is the increased production of fine concentrate unsuited for blast furnaces, but all right for reverberatories. Flotation also rises as a definite competitor and threatens the popularity of copper leaching (though acid leaching is restricted to oxidized ores). The suitability of flotation must be determined wholly by experiment, varying the conditions as to oil, acid, temperature, and combination of these elements.

The Inspiration Consolidated Copper Co. is operating the largest flotation plant in the world, namely, 15,000 tons of ore per day. This was erected as the result of experiments made in its 600-ton plant, now dismantled, where 172,722 tons were treated during 1914, according to W. Motherwell.[1] The mine contains nearly 100,000,000 tons of 1.63 per cent. ore, mostly in the form of chalcocite. In the test-mill every type of machine for crushing and concentrating was tried. The following methods of flotation were examined: 8, 12, 8, and 8-compartment Minerals Separation machines of standard type, each with certain modifications; a Towne-Flinn plant or bubble concentrator; a Callow plant of five cells and cleaner; a Cole machine; and an Inspiration machine.

The accompanying sketch shows one of the 18 sections at work in the new mill.

At the Engels mine, Plumas County, Cal., a flotation plant is treating over 200 tons of 3.8 per cent. copper ore per day, according to T. T. Read.[2] It cost about $50,000, and is in an out-of-the-way place. Rolls, classifiers, and a tube mill, produce a pulp that 65 per cent. passes 150-mesh. This goes to a 12-cell standard Minerals Separation flotation machine. The oil added amounts to 0.4 lb. per ton of ore, half of which is fed to the tube mill and the remainder to the different cells. The froth from the first three cells is drawn off as a finished concentrate. The froth from the remaining cells is returned to the first cell for re-treatment. The present total extraction averages 84 per cent. The soluble (in dilute sulphuric acid) copper ranges from 0 to 0.4 per cent. About two-thirds of this is recovered, the variation in the amount present leading to a corresponding variation in recovery. The concentrate froth is sent to a settling tank outside the building, and the thickened froth then goes to an 8-ft. diam. by 6-ft. face Oliver filter, which produces a cake averaging 10 to 12 per cent. moisture. This is dried to 5 per cent. for shipment to Garfield, Utah. It will be seen that this is an example of straight concentration by flotation.

[1] *Min. Sci. Press*, July 31, 1915.
[2] *Min. Sci. Press*, July 3, 1915.

On Jan. 25, 1916, the last section of the re-modeled concentrator of the Washoe reduction works at Anaconda, Mont., was placed in commission. There are eight sections, each of 2000 tons daily capacity, giving a total of 15,000 tons per day, when repairs, etc., are allowed for. The equipment for each unit includes the following, No. 1 being slightly

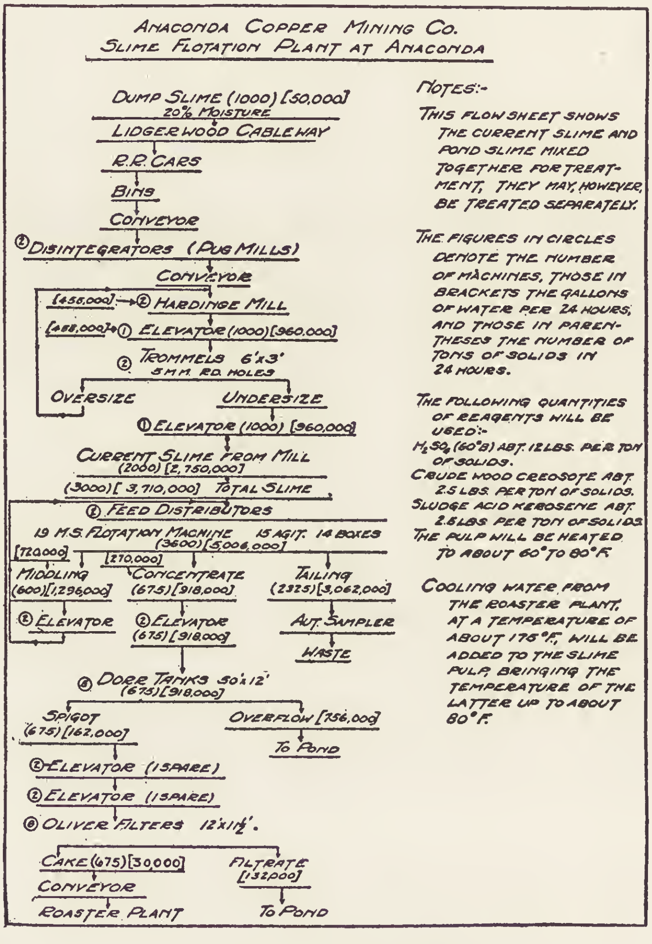

Fig. 5.—Flow sheet, Anaconda mill.

different, using Hancock jigs, and 8 by 12-ft. tube mills: One 12 by 24-in. Blake crusher, two 8 by 20-in. Blake crushers, six coarse concentrate Harz jigs, six ⅜-in. concentrate Evans jigs, 12 fine concentrate Evans jigs, four sets of 55 by 24-in. rolls, 18 Wilfley tables with Butchart riffles, eight 8-ft. Anaconda classifiers, six 7½ by 72-in. Hardinge mills with individual 225-hp. motors, using steel lining and steel balls, six Dorr simplex classifiers in closed circuit with Hardinge mills, and four Minerals Separation flotation machines having 15 agitators and 14 spitzkasten each, and individual 150-hp. motors. Also the necessary elevators, trommels, and dewatering tanks.

The mineral that is 2 mm. and under in size is sent to the Hardinge mills for re-grinding, in closed circuit with Dorr classifiers. The overflow from the latter goes to the flotation division, and the classifier-sand is returned to the Hardinge mills, according to E. P. Mathewson.[1] In the flotation department are three Minerals Separation machines in each section, while the slime from the upper part of the mill removed on the overflow of Anaconda classifiers is treated in a fourth machine after being thickened to 16 per cent. solids in a 28-ft. Dorr thickener. Below are six Callow cells for cleaning the concentrate. The remainder of the slime with 1000 tons daily from an old deposit is treated in a special slime flotation building, fitted up with 20 M. S. machines. Each machine has 15 gun-metal agitators and 14 floating-compartments. About 6 to 8 lb. of 50° B. sulphuric acid is added per ton of flotation feed, also 2 to 3 lb. of kerosene-sludge acid and 0.5 to 1 lb. of wood-creosote. The pulp is heated to 60 or 70° F. The concentrate from the M. S. machines is thickened in Dorr thickeners—50 ft. diam. and 12 ft. deep—and the thickened material is filtered in Oliver filters, from which it is conveyed on belts to the roasting plant. The tailing is sluiced to the dump by waste water from the mill.

The horsepower required per ton of ore is 0.96 as given by Mr. Mathewson at the March meeting of the Canadian Mining Institute.

The average grade of feed to the mill is 3 per cent. copper. Of the feed, 25 per cent. is removed in the upper part of the mill in the form of concentrate by water concentration; and 11.5 per cent. is recovered as concentrate from the flotation machines. The average tailing (slime and sand) contains 0.15 per cent. copper. This, after allowing for loss in overflow and leakage, gives a net recovery in form of concentrates of 96 per cent. of the copper in the original ore.

For the September, 1916, meeting of the American Institute of Mining Engineers to be held in Arizona, a comprehensive paper on "Flotation Concentration at Anaconda," has been prepared by Frederick Laist and Albert E. Wiggin.

The mill staff of the Braden Copper Co. described the operation of its mill in October.[2] The plant is on a hillside, and there is a difference of

[1] *Min. Sci. Press*, Aug. 28, 1915.
[2] *Teniente Topics*, Sewell, Rancagua, Chile.

elevation of 403 ft. from top to bottom. Gyratory-crushers, Symons disc-crushers, rolls, and Hardinge mills make a product of which all but 10 per cent. passes 60-mesh. Wilfley tables separate some mineral. Eight standard Minerals Separation machines do the final concentration, using oil and sulphuric acid. Dorr thickeners, an Oliver filter, and Kelly filter-press dewater the concentrate. In treating 4000 tons daily there is used 7 lb. acid, 2 lb. tar-oil, and 0.3 lb. fuel-oil per ton milled.

The simplifying influence of flotation is seen in the elimination of some Wilfley tables and all vanners in the Nevada Consolidated Copper Co.'s mill.[1] Gyratory crushers, rolls, trommels, re-grinders, and classifiers feed Janney flotation machines, which are doing good work.

Flotation and other changes at the Consolidated Arizona Smelting Co.'s mill at Humboldt, Arizona, increased the copper recovery by over 20 per cent.[2] over the best saving previously made with jigs, tables, and vanners. The ore is a siliceous sulphide containing pyrite and chalcopyrite, in a gangue of quartz and schist. In September, 1915, 7173 tons of 2.7 per cent. copper ore was treated. The recovery of copper was 90.9 per cent., flotation accounting for 75 per cent. of the total. Some old tailing was also treated. An 11-cell Minerals Separation machine is used in flotation, being one of the first in the United States to adopt it. The old system of treatment has been much simplified. It is found that pyrite concentrates easily on tables, but less readily than chalcopyrite. About 60 per cent. of the flotation product is finer than 200-mesh. No acid is used. The temperature is that of the mill. Oil is added continuously to the inflowing pulp, and the mixture then passes successively through the 11 cells of the machine, with no re-treatment or cleaning of concentrate. Close attention is paid to the chemical condition of the ore. A splendid recovery is made on clean, bright, fresh sulphides, but when the minerals become tarnished or oxidized slightly, the flotation froth is almost immediately killed, reducing the extraction. Two parts of stove-oil and one part No. 200 oil (refined wood-creosote) is used. The total cost of concentration is $1.03 per ton; flotation, exclusive of royalty, being 27 cts. per ton. The flotation machine consumes 32.7 kw. When the capacity is increased to 400 tons per day, costs will be under 90 cts. per ton.

"Flotation at Globe-Miami, Arizona,"[3] briefly describes general features at the Miami, Inspiration, and Old Dominion mills.

Plans for a 600-ton flotation plant are being prepared for the Moctezuma Copper Co., Nacozari, Sonora, Mex. Various machines were tried in 1915, and it was proved possible to obtain a good mineral froth

[1] Editorial correspondence, *Met. Chem. Eng.*, Oct. 15, 1915.
[2] Editorial correspondence, *Met. Chem. Eng.*, Dec. 1, 1915.
[3] *Eng. Min. Jour.*, Dec. 18, 1915.

without the use of acid. Last year the mill treated by water concentration 424,027 tons of 3.412 per cent. ore, with 83.6 per cent. recovery.

Very satisfactory progress was made during 1915 with oil-flotation work, according to the report of the Old Dominion Copper Mining & Smelting Co. of Globe, Ariz. The Minerals Separation machine originally installed was used to treat all of the slime. Experiments were made with other types, and will continue to be made during 1916. Rather expensive reagents first used in flotation were replaced by cheaper ones, and a distinct improvement in oil costs has recently been effected. In treating 173,046 tons of 4.34 per cent. copper ore, the recovery increased from 73.55 to 85.27 per cent.

At the Burro Mountain copper mine, New Mexico, where two 500-ton flotation units should be working in May, 1916, using Rork machines, 11,009 tons of ore was experimented with before deciding on the type of reduction and treatment.

Many dumps of tailing are being treated by flotation, and many await exploitation by this process. At the old Cactus mine, at Newhouse, Beaver County, Utah, the Utah Leasing Co. is operating a 500-ton plant on 1,000,000 tons of tailing. Flotation is the sole means of concentration, according to Herbert Salinger.[1] Hardinge mills and Dorr classifiers in closed circuit deliver minus 65-mesh pulp to a Minerals Separation 6-6 combination-type machine; that is, six standard single-spitz cells, and six double-spitz sub-aeration Hibbard cells. A light coal-tar creosote, combined with kerosene acid-sludge gives the best frothing. An alkaline solution gives best results. Recovery is from 80 to 85 per cent. The mineral is mostly chalcopyrite, with a little gold and silver.

Gold and Silver Flotation and Cyanidation

"Flotation: Its Sphere of Usefulness in Gold Metallurgy" is the title of a paper by W. B. Blyth,[2] who thinks that the application of flotation to the concentration of gold ores is only a question of time. Already plants have been erected in this connection, and operated successfully. The process has reached the stage where its sphere of usefulness is not confined to the base metals. It must be recognized as a commercially applicable process by gold investigators also, and it is as well now to consider its possibilities. In the first place, being a concentration process, it is of value only where the valuable constituents of the ore are in the mineral, or when some refractory mineral is present in an otherwise free-milling ore, and it is desired to remove that mineral subsequent to cyanidation. In this latter connection the flotation

[1] *Salt Lake Min. Rev.*
[2] *Bull. Aust. Inst. Min. Eng.*, 1914.

process seems to have an extended field of usefulness in the preliminary concentration of cupriferous gold ores. These have been a bugbear to metallurgists for many years, not because the copper interferes with the dissolution of the gold, but because it consumes so much cyanide during the process. A small percentage of chalcopyrite will render the treatment of a low-grade gold ore unprofitable under existing conditions. The flotation process will remove the copper in the form of a marketable concentrate, and will do it effectively and at small cost. The remaining pulp will be in a fit state to undergo ordinary cyanide treatment. It is doubtful if it will ever pay to float mineral from an ore that yields its gold readily in an all-sliming process. It must be remembered in this case that the mineral that is slimed in a circulating cyanide solution during crushing will yield its gold by simple, inexpensive agitation. The coarse mineral can be removed, classified, and slimed in the usual manner, and the slimed product mixed against with the rest of the pulp prior to agitation. If the mineral is floated off, then the same ultimate procedure must be adopted with the floated portion. The additional expense of flotation will be incurred, as against the cost of agitation and filtration of a large proportion of more or less barren tailing. The latter will generally be found the cheapest and least complicated process. When studying the features of roasting refractory floated concentrate prior to cyanidation, it must be remembered that the standard flotation process is particularly efficacious in floating mineral slime. As tables do such excellent and cheap work in separating the coarse mineral, it may be said that, as regards gold ores, the chief field for flotation lies in the concentration of refractory slime. It must be borne in mind that the roasting of slime from a cyanidation standpoint is a difficult problem, and one that, as far as information is available, has never been solved; this is a problem in itself. Investigators should be warned that the mere fact of being able successfully to float the valuable mineral in a given slime does not indicate that it can be successfully treated, unless there is a smelter handy to buy the concentrate. Mr. Blyth considers that flotation will certainly occupy a prominent place in gold metallurgy during the next decade, but predicts that there will be many commercial mistakes made in its application during that period.

Flotation promises in the future to take a very important part in the treatment of sulphide gold ores, according to A. E. Drucker.[1] It is going to be a serious competitor of the cyanide process. The weakness of water-concentration methods during the past has been with the treatment of that product passing a 200-mesh screen, commonly called "slime." Where the sulphides are finely disseminated through an

Min. Sci. Press, Nov. 20, 1915.

ore and comparatively fine grinding is necessary, and all-flotation process would then be in order.

Concentrate from gold-silver ore reduction is generally high grade and refractory but does not yield readily to treatment, unless it be smelting, which is costly, apart from freight and losses. To treat such a product by cyanidation, preliminary water, acid, or alkali washing, roasting, fine grinding, the use of special solvents (such as bromo-cyanide), and prolonged contact of the material with cyanide (over a month in some cases), are in vogue, according to Charles Butters and J. E. Clennell.[1] A flotation concentrate from a similar ore would have the same minerals as from gravity concentration, but the oil or other flotation agent adds to the difficulty of subsequent cyanidation. Numbers of experiments were made on ore from the San Sebastian mine, in Salvador. It assayed 1.54 oz. gold and 0.28 oz. silver. A flotation concentrate contained 4.92 oz. gold and 1.14 oz. silver, 0.8 per cent. copper, 24.3 per cent. iron, 26.2 per cent. sulphur, and 44.3 per cent. insoluble. It was concluded that roasting, water-washing, and cyaniding the concentrate was the best treatment, giving 96.8 per cent. of the gold. There was a saving of 48 cts. per ton of raw ore in reduced cyanide consumption, and on a monthly output of 3500 tons the total gain in better recovery, reduced cost, etc., was $2.74 per ton.

Flotation of gold ores, according to Charles Butters,[2] will be used in connection with water concentration, and that its best place in a gold and silver mill is in the treatment of slime. A common method for the treatment of precious-metal ore will be concentration by water and the treatment of the resulting sand by cyanide, with the use of flotation for the slime. A scheme like this could be adopted in many cases, thus obviating the necessity for fine grinding. The removal of the pyrite from the sand and the flotation of the slime, which would do away with the most expensive part of the cyanide plant, namely, the slime annex. However, the constantly recurring question would be: what to do with the flotation concentrate? A flotation concentrate low in solubles is desirable, because if the concentrate is to be handled or shipped, it should contain the lowest possible percentage of insolubles.

Gold ore at the Gold King mine at Gladstone, San Juan County, Colo., is treated as follows: Gyratory-crusher, stamps, 24-mesh screens, Richards' pulsator classifiers, Wilfley and Card tables, Card slime tables, and Callow cone. The flotation plant, which was developed by L. C. Bastian, according to Warren C. Prosser,[3] treats the middling and slime products from the second re-treatment tables. The system consists

[1] *Min. Sci. Press*, Nov. 20, 1915.
[2] *Min. Sci. Press*, Dec. 2, 1915.
[3] *Eng. Min. Jour.*, Oct. 16, 1915.

of eight agitator-boxes with impellers working at 465 r.p.m., six frothing-boxes, four Card froth-breaking tables, and a settling tank. Carbolic, creosote, and pine-oils are added at three different points, 300 c.c. of total oil per ton of pulp being used. As the mine-water contains sulphuric acid, no additional acid is required. Concentrate is worth $40 per ton, with 28 per cent. silica. The recovery of metal is 85 per cent. Finer grinding is proposed for more flotation work.

In discussing flotation and cyanidation editorially,[1] a writer says that not the least of the new problems is the cyanidation of flotation products, that is concentrate and tailing. In fact, the future development of flotation may have an economic bearing on the continued use of the cyanide process in some places. Difficulty is found in treating a flotation product by cyanide, but the trouble is not regarded as insurmountable.

Treatment of low-grade gold ore by cyanidation at Cripple Creek, Colo., has been done by the Portland and Stratton mills, with fair recovery and low cost; but flotation is to supplement this process. The Vindicator Consolidated Co., did a lot of experimenting in 1915, and is remodeling the concentrator at the Golden Cycle shaft into a flotation unit of 300-ton daily capacity, to treat, reject from the ore-house, etc. An extraction of 90 per cent. at a cost of $1 per ton is anticipated. A 1000-ton mill will follow later. For flotation this will cost $200,000; for cyanidation it would be $750,000.

"One can not say that flotation is a panacea for all kinds of metallurgical troubles, but it is a process that every metallurgist must learn, because if he does not ascertain whether there is a place for it in his flow-sheet he will be missing big chances. . . . . . Every silver mill should ascertain whether flotation is applicable. . . . . . A high-grade concentrate is obtainable from Mexican silver ores, even from the dumps. An ore assaying 0.1 oz. gold and 10.1 oz. silver per ton contained only 0.01 oz. gold and 0.15 oz. silver after flotation; while another carrying 0.52 oz. gold and 15.94 oz. silver, from which the tailing assayed 0.035 oz. and 2.07 oz. respectively. . . . . . It is possible to beneficiate an enormous quantity of low-grade ore not available hitherto for treatment, without additional capital expenditure for power. . . . . . In machines the necessity for a most intimate mixing of oil and ore, after which quiescence is necessary in order that the bubbles may not be broken, thus facilitating a cleaner separation. It seems that the two stages of treatment should not take place in the same machine."—Charles A. Butters in an interview.[2]

An ore containing 0.1 oz. gold, 35.4 oz. silver, 0.25 per cent. copper, and 0.7 per cent. lead is one not liked by cyaniders on account of the

[1] *Met. Chem. Eng.*, Dec. 1, 1915.
[2] *Min. Sci. Press*, Aug. 21, 1915.

base metals, but it is the average product of a Mexican mine.[1] Gravity concentration yields a product assaying 2 oz. gold, 570 oz. silver, 2 per cent. copper, and 10 per cent. lead, fit material for a smelter, but the table tailing of 0.03 per cent. gold, 18 oz. silver, 0.15 per cent. copper, and 0.4 per cent. lead has still undesirable minerals for cyanidation. Some zinc also occurs, and this with the copper fouls the cyanide solutions. Over 90 per cent. of the metal in the original ore occurs in the form of sulphides. After making further concentration tests, flotation was tried; first in the laboratory, then on a practical scale with run-of-mine ore and a section of the mill. Several flotation machines were tried, and what is termed a "submerged agitation" was evolved, giving a much richer concentrate. Oil consumption is expected to be ¼ lb. per ton of ore. The cyanide consumption was 6 lb. per ton, but in treating flotation tailing this will be reduced to 1 lb. In the treatment of 5761 tons of ore per month, taking everything into consideration, the increased profit due to flotation is estimated at $7028, equal to $1.22 per ton of ore.

Silver produced at Cobalt, Ont., amounts to 24,000,000 oz. per annum, extracted from a complex ore, containing arsenic, cobalt, and nickel, also some mercury. Metallurgical problems have been numerous, and solved with great skill, but flotation is going to help cyanidation. The Buffalo company is erecting a plant to treat 600 tons daily, the Dominion Reduction has a 5-ton unit for experimental purposes, the McKinley-Darragh plant will deal with 150 tons, and the Nipissing has a 20-ton test-plant at work. Cobalt metallurgists are sanguine about the success of flotation on their ores.

Some of the gold-copper ore is treated by flotation at Mt. Morgan, Queensland. During the 6 months ended Nov. 28, 1915, the mill treated 83,985 tons of ore averaging 2.057 per cent. copper, and $5.29 gold. This gave 19,318 tons of table concentrate, assaying 2.852 per cent. copper and $9.39 gold, also 4705 tons of flotation concentrate containing 20.782 per cent. copper and $29.99 gold. Recoveries were 31.89 per cent. copper and 40.82 per cent. gold on tables, and 56.60 per cent. copper and 31.76 per cent. gold by flotation, a total of 88.49 per cent. and 72.58 per cent. respectively.

Machines and apparatus developed by and used in cyanidation are nearly all applicable to flotation, such as gyratory and jaw-crushers, rolls, Symons disc-crushers, Marcy ball mills, Hardinge mills, tube mills, Wilfley, Deister and other tables, Richards classifier, Dorr classifier, Akins classifier, belt-elevators, slime-pumps, Dorr thickeners, and Oliver filters, Kelly presses, and many other worthy machines. Prac-

[1] Anon, *Min. Sci. Press*, July 24, 1915.

tically the only new apparatus is that for flotation itself, all the others fitting in without trouble.

Lead

The new 200-ton per 8-hr. shift mill of the Daly West Mining Co., Park City, Utah, treats a lead-zinc-silver ore, according to L. O. Howard.[1] The system includes a Blake jaw-crusher, Symons disc-crusher, Blake-Denison weighing machine, trommel, Franz jigs, Harz jigs, Wilfley tables, re-grinding rolls, Richards-Janney classifier, and Akins classifier. The feed to the flotation department consists of slime from the Richards-Janney machine. The unit consists of two mixing-cells and 14 flotation cells, with a capacity of 30 tons of dry slime daily, similar to that used by the Federal Lead Co. in Missouri. Each cell is 4 ft. 4 in. long by 20 in. wide, and 5 ft. 8 in. deep at the tailing discharge end. Each flotation cell has two compartments, one similar to the mixing-cells and another longer one, where the flotation is effected. Propellers are used for agitation. A flotation concentrate is taken off each cell, the tailing passing through the whole system of cells in series. Pine-oil is added drop by drop into the first mixing-cell. The consumption of oil is 0.4 lb. per ton of slime treated. One 50-hp. motor drives 16 propellers of the flotation machine and 14 concentrate skimmers. Flotation here has replaced the complicated classification and re-treatment of slime.

The Coeur d'Alene region of Idaho produced 1,000,000 lb. copper, 351,055,000 lb. lead, 12,199,000 oz. silver, and 92,310,000 lb. zinc in 1915, giving the State second place in the Union as a lead and sixth as a zinc producer. The metallurgical problems of the region are varied, according to Herbert A. Megraw;[2] some ores are simple, others are very complex. It is a characteristic feature that the mines in different parts produce ores of a widely different character. Bunker Hill and Sullivan ore is not troublesome, but that of the Morning is complex and difficult to treat. Skilled metallurgists have investigated the troubles for years. Quartz is found largely in the deposits. Siderite, the carbonate of iron, is the most abundant characteristic gangue mineral of the silver-lead deposits, and has an important influence on metallurgical work. Table and jig concentration did not recover as much of the minerals as was desired, but the introduction of flotation in nearly all of the mills makes a much larger extraction, due to its efficacy of slime treatment, where the losses formerly occurred.

The Silver Peak mine, New South Wales, produces an ore containing galena, pyrite, marcasite, arsenical pyrite, blende, chalcopyrite, and

[1] *Met. Chem. Eng.*, Sept. 15, 1915.
[2] *Eng. Min. Jour.*, Nov. 20, 1915.

other minerals of minor importance, according to H. Hardy Smith.[1] The galena carried silver, also the iron sulphides, especially the marcasite.

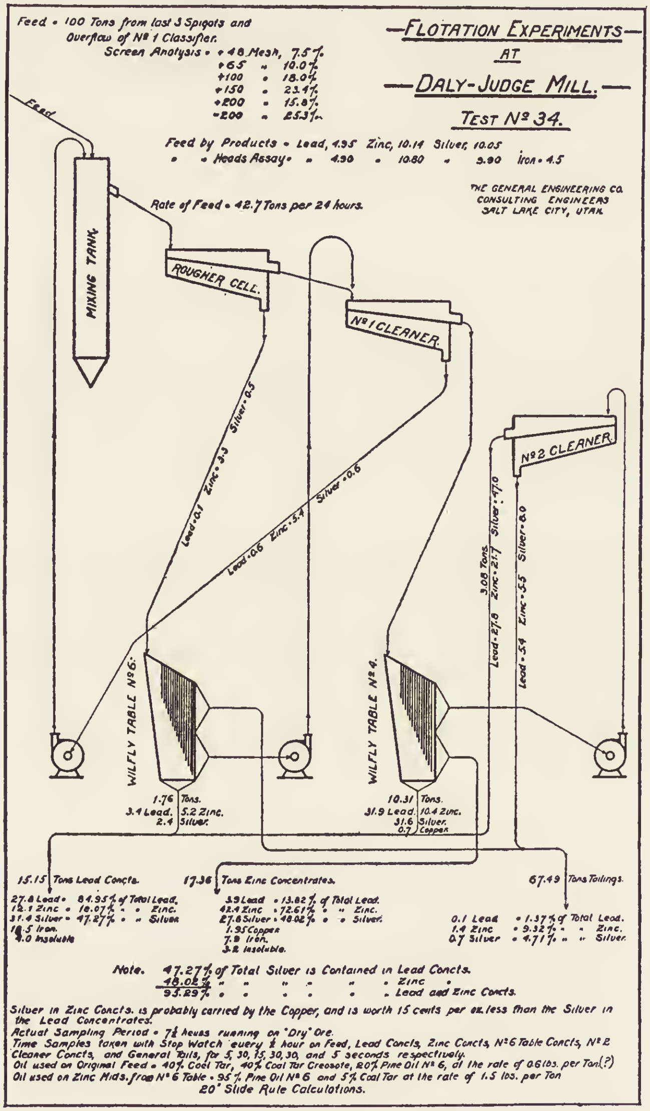

FIG. 6.—Flow sheet, Daly-Judge mill.

As the ore was soft and friable it slimed badly in crushing. Table concentration gave low recoveries; a Minerals Separation plant resulted in

[1] *Eng. Min. Jour.*, Dec. 11, 1915.

satisfactory results. A temperature of 120° F., 20 to 30 lb. acid per ton, and ¾ to 1½ lb. *eucalyptus amygdalina* as an emulsifying agent, and 2 to 2½ lb. of mineral-oil mixture per ton was used to maintain the froth. A special device was arranged to remove the dense and heavy froth.

Losses of lead and zinc at the Daly-Judge mine, Utah, have been in the fines, but with the flotation unit at work these have been greatly reduced, and the mill placed in condition to do work consistent with the latest and best practice of wet concentration, as well as place it in position to take advantage of improvements, which will unquestionably be made in methods of oil concentration.[1]

Zinc

Among the zinc mines at Butte, Mont., is that of the Elm Orlu Co., whose ore is treated in the 500-ton plant of the Timber Butte Milling Co. The ore, according to Theodore Simons,[2] carries zinc (18.52 per cent.) and lead (0.75 per cent.) in sphalerite and galena; copper (0.73 per cent.) in bornite, chalcocite, tennantite, and tetrahedrite; and gold (0.013 oz.) and silver (6.23 oz.) either free or chemically combined with the sulphides of the base metals. The gangue is chiefly quartz, barite, fluorite, rhodonite, and rhodocrosite. The iron (3.29 per cent.) occurs as iron pyrite. The mill is 13 miles from the mine by rail.

Considerable testing was done prior to its erection, and products for copper, lead, and zinc smelters were the aim of this work, the precious metals to go with each of these. In sequence is the following plant: 750-ton storage-bin for crude ore, shaking-screen feeder, Farrel jaw-crusher, steel elevator, Symons pulsating screen, Symons disc-crusher, belt conveyor, ore-bin, apron-feeders, belt conveyors, Garfield rolls, elevator, Garfield rolls, impact-screens, mechanical-distributor, Wilfley roughing-tables, Akins classifiers, elevators, dewatering box, distributor, Hardinge mills, elevator, mechanical distributor, James sand-tables, elevator, Richard's hindred-settling classifier, Harz jig, Wilfley tables, James sand-table, distributor, Akins classifiers, Hardinge mills, elevator, and sludge tank. A recovery of 25 to 30 per cent. of the total original zinc in the ore is made on the roughing-tables, the Wilfleys producing a 50 per cent. zinc concentrate. The last-mentioned Hardinge mills produce pulp with a maximum of 60-mesh.

In the flotation section, the final separation of the fine sulphides from the gangue takes place. The pulp from the sludge tank flows to a standard 600-ton M.S. unit, known as the rougher machine. It has 11 cells, each divided into a mixing or agitating and flotation compartment.

[1] Abstract of report of the general superintendent, O. N. Friendly, for 1915.
[2] *Bull. Amer. Inst. Min. Eng.*, June, 1915.

The pulp density is 3 of water to 1 of ore, and this is kept at a temperature of 130° F. Sulphuric acid is mixed at the rate of 7 lb. per ton of original ore, and 0.5 lb. oil per ton. The flotation agitators run at 265 r.p.m. The pulp passes through the 11 cells in series, the first seven floating the clean sulphides and richer middling. Middling overflowing from No. 7 to 11 are re-ground in Hardinge mills, and returned for flotation. Concentrate from the first six cells of the rougher machine is sent to the first and fifth cells of a 200-ton Minerals Separation unit, of eight cells. This is the finisher, and produces a concentrate with 52 per cent. zinc, and some copper, iron, and lead. Some further separation of these is done on James tables. The clean middling from the fourth and eighth cells of the finisher are re-ground and again floated. The total recovery is 96 per cent. of the zinc, and 92.6 per cent. of the silver, at a cost of around $2 per ton. Power consumed is 1.99 hp. per ton of ore milled.

During January, 1916, the Butte & Superior Co.'s mill at Butte, Mont. treated 49,429 tons of ore, yielding 10,535 tons of zinc concentrate, worth $101.16 per ton, at a cost of $3.05 per ton. A recovery of over 90 per cent. is effected by table concentration and flotation.

George Belchic and Glenn L. Allen[1] discuss the flotation of Joplin and Galena slime, which constitutes that material overflowing from the settling tanks and deposits in slime-ponds. There are two classes, that formed from free-milling ore, and that from the "chatty" ore in which the minerals are finely disseminated. Of the latter 99 per cent. passes a 150-mesh screen, and assays 6.55 per cent. zinc, and the former 95 per cent. through this screen and contains 7.82 per cent. metal.

Over 100 laboratory tests were made with the following results: (1) Good results were obtained without the use of sulphuric acid. (2) A temperature of 60° C. gives better results with light pine-oils and rape-seed oil, while 25° C. is better suited for heavy tar-oils and crude petroleum. (3) The best speed of agitation was between 1200 and 1500 r.p.m. Above that speed the gangue was often thrown over with the froth. (4) Pulp dilution varies with the fineness of the slime. A 7 to 1 dilution was satisfactory with very fine slime; with coarser, 3 to 1. (5) The most satisfactory oils were: pine (2.5 lb. per ton with 10 lb. sulphuric acid); rape-seed (10 lb. per ton and no acid); benzine-sulphuric acid and tar-oil, 1 to 1 (8 to 10 lb. per ton); and carbon-bisulphide and rosin-oil, 1 to 1 (5 lb. per ton).

A mixture of sphalerite, intimately mixed with magnetite, pyrite, pyrrhotite, specularite, galenite, and chalcopyrite in a lime and tremolite gangue, is treated at the Graphic mine at Magdalena, N. M., by surface tension or "film flotation," according to Philip Argall.[2] It is termed this

[1] *Met. Chem. Eng.*, Nov. 15, 1915.
[2] *Min. Sci. Press*, Jan. 22, 1916.

in distinction from the scum or froth that is allowed to accumulate in a thick layer by other methods. The same crude mineral oil that is used in the Diesel engine is used in flotation. The ore is agitated with oil and acid, and presented in large open vats to a surface of briskly moving hot water, on which the oiled particles float away rapidly as a thin film, and the unoiled particles sink. The latter passes to other mixers for further chance to float. Over 50 per cent. of the pulp passes 200-mesh. The recovery is 95 per cent., making a 45 per cent. zinc concentrate from 16 per cent. zinc ore in one operation. The system is the Ozark flotation process. Mr. Argall considers that the future of flotation lies in slime treatment.

Flotation greatly increased the recovery of zinc concentrate from the complex lead-iron-copper-zinc ore of the Mary Murphy mine, Romley, Cool., according to George E. Collins' report for 1915. Marketable products were made at a low cost by this system. The flotation difficulties were not all overcome; novel and puzzling difficulties constantly arose. The process is used only on slime, and the crude ore will probably never be treated direct by it.

Recovery of zinc and lead is as good as any at the Consolidated Interstate-Callahan mine, Coeur d'Alene, Idaho according to the last report of the general manager, John H. Robbers. The mill treats over 10,000 tons of ore monthly, using table concentration and flotation.

Flotation at the Amalgamated Zinc (De Bavay's) plant at Broken Hill has treated 2,562,000 tons of tailing, yielding 730,000 tons of 49 per cent. zinc concentrate to June 30, 1915. The war interfered with work considerably during the 6 months ended at that date but 156,196 tons of material was treated for a yield of 43,468 tons of concentrate, assaying 49.3 per cent. zinc, 5.5 per cent. lead, and 7.9 oz. silver; also 420 tons of concentrate, assaying 58.5 per cent. lead, 57.9 oz. silver, and 11.7 per cent. zinc.

Other Minerals

Flotation is not restricted to the base metals, some of the rarer ones being amenable, notably molybdenum. The concentration of the mineral molybdenite has been a source of worry, as it is soft and flaky and tends to float away in water concentration. For some time in Denver, the Henry E. Wood works has been treating molybdenite from various sources, and valuable information is given by Mr. Wood in a recent paper.[1] The data given is from the treatment of over 200 tons of simple and complex ores from Canada and the United States. Fine but distinct crystals that are uniformly distributed through the gangue constitute

[1] *Bull. Can. Min. Inst.*, Mar., 1916.

a much more desirable ore for concentration by flotation than an ore containing large and irregularly distributed crystals, because an ore of uniform character is simple of treatment, likewise the equipment. The value of mechanical concentrating *v* hand-sorting, and fine-grinding is tersely discussed. Two flow-sheets are given for treatment by the Wood system.

The machine is shown in the accompanying sketch, and needs little additional description. At the back of the tank is supported a brass

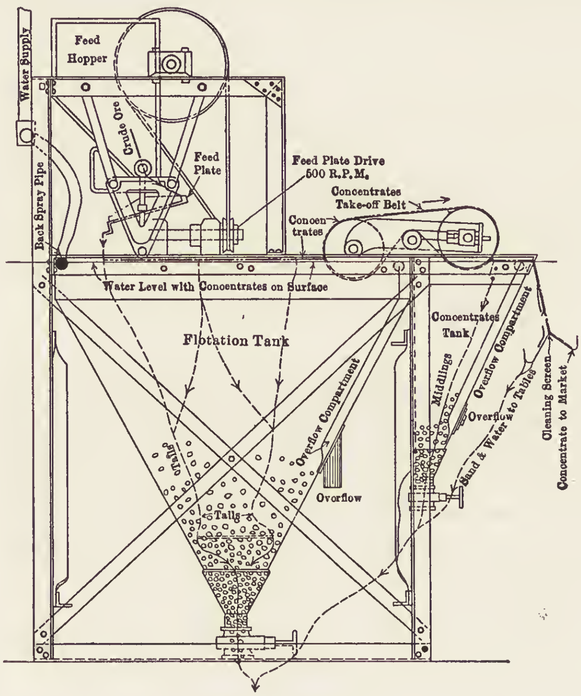

Fig. 7.—Wood cell.

spray-pipe, which discharges a large number of fine jets of water parallel to, and just below the surface of the water in the tank, thereby creating a swift and smooth surface current toward the front of the tank. Half-way between the back spray-pipe and the front of the tank is a second spray-pipe with a smaller number of holes, assisting the back pipe to maintain the surface current uniform across the tank. The power consumed is about 0.25 hp., and water required from 5 to 10 gal. per min. In operation the dry-crushed ore, sized or unsized, falls (height adjustable from ¼ to 4 in.) from the hopper to an inclined vibrating-plate, and then to the surface of moving water in the tank. While passing over the surface of the tank, most of the gangue is wetted and sinks. The molybdenite film adheres to the emerging belt (see sketch) is lifted out of the tank, and at the point where the belt reverses its traveling direction, it meets the level of the water in a smaller tank and leaves the belt. It then falls on a vertical dewatering screen. Middling in the second tank is re-treated. The concentrate is dried, sampled, assayed, and shipped.

Associated minerals affect good results somewhat, but are not very troublesome. Preparation of the ore is an important factor. The machine is best fed direct from the ball mill, about −16-mesh. Tests of 60 to 70 samples of Canadian molybdenite show that up to 95.64 per cent. can be recovered by flotation.

At two mines in Norway the Elmore process is successfully treating molybdenite.[1] Ore crushed to 30-mesh gave a recovery of 91.7 per cent., making a concentrate containing 84.8 per cent. MoS_2.

Treatment of quicksilver ores by flotation has been under investigation for some time, and interesting information should be forthcoming from the New Almaden mine, California, during 1916.

Smelting Flotation Products

Modifications in smelting practice must be made to cope with concentrates produced by flotation plants. This product is mostly very fine, and needs preliminary treatment prior to reduction. The reverberatory is available for copper and lead concentrate, but the retort is not entirely suitable for zinc concentrate, and electrolytic treatment will probably be found a competitor for this.

In treating 4000 tons of ore per day, the Braden mill[2] (using flotation) produces 350 tons of concentrate, assaying 19 per cent. copper, 17 silica, 23 iron, 2 lime, 8 alumina, and 28 per cent. sulphur. Of the total, 62 per cent. is nodulized, 14 per cent. sintered, and 24 per cent. reduced direct (raw) in varying proportions in blast furnaces.

In describing the gas-fired reverberatory furnace at Sulitjelma, Norway, which is used for smelting concentrate, C. Offerhaus[3] mentions that over 80 per cent. of the mill-tailing (1 to 1.6 per cent. copper) is saved in the Elmore concentrate. The Elmore process has been successfully operated for several years. The residue contains 0.13 to 0.25 per cent. copper. Oil consumption is 2 liters per 1.2 tons of mill-tailing. The concentrate is roasted in a Wedge furnace, and then reduced in a reverberatory of the Anaconda type.

[1] *Eng. Min. Jour.*, May 22, 1915.
[2] *Teniente Topics*, Nov., 1915.
[3] *Eng. Min. Jour.*, Dec. 25, 1915.

Disposal of Flotation Residue

Disposal of flotation residue is just as much a mechanical process as it is from cyanide plants. It is considered by W. Shellshear[1] generally advisable to thoroughly dewater the residue from flotation treatment in order to form a closed circuit of liquor. In Australia the systems are filtering in vats, a combination of submerged draining-belt and Dorr thickeners, and a combination of Caldecott diaphragm-cones, draining-belt, and Dorr thickeners. A combination of Dorr classifiers and Dorr thickeners would give good results. Drained products may be disposed of by inclined conveyor-belts and boom-stackers, aerial trams, trucking, and sluicing.

Recoveries by wet concentration, flotation, and leaching processes are compared in an editorial,[2] in which it is stated that the average recovery of the five porphyry mills (tables, etc.) is 68.03 per cent., flotation on various ores 75 to 90.3 per cent., and 80 to 85 per cent. by leaching. The fields for application of these processes overlap to a certain extent; but the processes are not interchangeable and none is universally applicable.

A bibliography on any subject is of value, especially when referred to as frequently as flotation, therefore the 104-page list of references on concentrating ores by flotation, compiled by Jesse Cunningham, librarian at the School of Mines and Metallurgy, University of Missouri, at Rolla, issued on Jan. 1, 1916, will be found a useful contribution to the subject.

[1] *Min. Eng. Rev.*, Melbourne, Australia.
[2] *Eng. Min. Jour.*, July 3, 1915.

DATA OF THE WORLD'S PRINCIPAL MINES

By S. F. Shaw

Compiled from Annual Reports of the Respective Companies

Name of Mine.	Location.	Year.	Tonnage Produced.	Profit.	Dividends.	Ore Reserves, Tons.	Cost per Ton.
Ahmeek	U.S.	1915	948,874	$2,264,882	$1,650,000	...	$1.83
Alaska Gold Mines	U.S.	1915	1,115,294	278,771	...	...	0.69
Alaska Juneau	U.S.	1915	179,892	...	...	...	...
Alaska Mexican	Alas-U.S.	1914	233,457	170,020	144,020	688,736	1.47*
Alaska Treadwell	Alas.	1914	910,285	1,351,403	1,100,000	7,159,253	1.49*
Alaska United	Alas.	1914	458,314	257,939	162,180	4,686,539	1.54*
Allouez	U.S.	1915	534,705	924,680	200,000	...	1.75
Amalgamated Zinc	Aus.	½–1914	247,386	290,000	...	...	...
		2/2–1914	165,438	£34,356	...	...	...
American Smelt. & Ref.	U.S-Mex.	1914	1,266,702	9,031,565	8,017,450	...	...
Anaconda	U.S.	1915	4,383,339	16,695,806	9,325,000	...	11.46
Arizona Copper	U.S.	'13–'14	1,079,950	£288,255	£157,521	...	3.56
Ashanti Goldfields	W.Af.	'14–'15	138,316	770,000	720,000	433,900	10.00
Associated Gold Mines	Aus.	'13–'14	127,856	£11,467	£12,384	33,306	5.35
Aurora Con.	U.S.	1915	138,399	—22,377	...	414,000	3.22
Baltic	U.S.	1915	378,443	949,965	...	...	...
Beaver Con.	Ont.	'15–'16	30,093	...	120,000	...	...
Blackwater	N.Z.	1914	50,426	£19,854	£12,499	104,564	...
Brakpan	Tran.	1914	622,573	£245,900	£225,000	2,490,000	4.79
British Broken Hill	Aus.	2/2–1914	28,512	—£17,610	...	1,053,250	...
British Columbia Copper	B.C.	1914	193,289	—39,765	...	...	...
Broken Hill North	Aus.	½–1914	156,020	£157,658	£150,000	...	4.33*
		2/2–1914	102,735	£106,121	...	3,000,000	...
Broken Hill Block 10	Aus.	2/2–1914	37,853	—£4,691	£12,500	...	...
		½–1914	23,810	£4,245	£10,000	...	7.64
Broken Hill Block 14	Aus.	2/2–1914	19,821	— £608	£10,000	...	9.25
Broken Hill Proprietary	Aus.	½–1914	139,991	£150,714	£107,050	...	...
		2/2–1914	121,316	£125,611	£59,050	...	...
Broken Hill South	Aus.	'14–'15	164,210	913,000	432,000	3,350,000	...
Brunswick	U.S.	1914	16,237	123,964	94,869	21,000	10.22
Brunswick Con.	U.S.	1915	22,004	72,565	71,152	16,000	6.86
Buena Tierra	Mex.	1914	16,307	£5,908	£16,500	300,000	5.14
Buffalo	Ont.	'13–'14	77,616	388,187	660,000	54,116	...
Bullfinch Proprietary	Aus.	1913	52,679	£50,572	£47,615	145,582	8.56
Bunker Hill Sullivan	U.S.	1915	455,205	1,145,854	1,062,750	3,573,930	6.66
Butte & Superior	U.S.	1915	522,300	9,125,947	4,908,115	1,000,000	5.11
Calumet & Arizona	U.S.	1915	664,152	...	2,006,557	...	...
Calumet & Hecla	U.S.	1915	3,188,583	...	...	...	2.08
Camp Bird	U.S.	'14–'15	32,313	£83,601	£100,475	15,900	16.91
Cape Cappe	Cap. Col.	'14–'15	83,143	£22,371	£5,400	510,900	...
Carn Brea & Tincroft	Eng.	½–1914	29,795	—£3,681	...	...	5.60
		2/2–1914	29,373	—£283	...	...	5.17
Centennial	U.S.	1915	150,191	142,439	...	...	1.95
Centennial Eureka	U.S.	1914	58,365	...	...	...	...
Champion	U.S.	1915	...	3,709,049	3,100,000	...	2.29
Champion Reef	Ind.	'13–'14	216,934	...	£138,667	477,384	...
Chino	U.S.	1915	2,379,800	6,913,984	2,609,890	90,000,000	1.84
City & Suburban	Tran.	1914	324,211	£248,550*	£204,000	758,700	5.06*
City Deep	Tran.	1914	505,800	£359,033	£296,875	2,510,800	5.83
Coniagas	Ont.	'13–'14	54,522	989,618	...	260,086	...
Cons. Langlaagte	Tran.	1914	578,100	£236,224	£190,000	2,220,707	4.15
Cons. Main Reef	Rand	'14–'15	294,866	£138,265	£115,545	855,600	5.00
Cons. Mining and Smelt.	B.C.	'14–'15	447,064	795,411	464,398	...	...
Copper Queen	U.S.	1915	830,777	...	...	14,330,421	...
Copper Range	U.S.	1915	1,651,870	3,564,762	1,182,003	...	1.31
Crown Mines	Tran.	1914	2,287,600	£990,573	£799,090	9,369,000	4.22
Crown Reserve	Ont.	1915	...	133,307	106,128	...	...
Daly-Judge	U.S.	1915	69,744	...	300,000	...	...
Davis-Daly Estate	U.S.	'13–'14	52,195	—108,020	...	...	...
Detroit Copper	U.S.	1914	477,582	...	280,000	...	...
Dolcoath	Eng.	½–1914	57,254	£510	...	...	5.73
		2/2–1914	48,058	£898	...	...	5.93

Note—Abbreviations used in above table: Alas. Alaska; Aus., Australia; B. C., British Columbia; Braz., Brazil; Can., Canada; Cap. Col., Cape Colony; Eng., British Isles (Cornwall); Hon., Honduras; Ind., India; Malay, Malay States; Mex., Mexico; N.S.W., New South Wales; N. Z., New Zealand; Port., Portugal; Rhod., Rhodesia; Sib., Siberia; S. A. South Africa; Tas., Tasmania; Tran., Transvaal; U. S., United States; W. Af., West Africa.

—Loss for the year. † Cubic yards. * Working cost. ½ First half. 2/2 Second half. All profits and dividends are in dollars except where otherwise noted.

Name of Mine.	Location.	Year.	Tonnage Produced.	Profit.	Dividends.	Ore Reserves, Tons.	Cost per Ton.
Dolores	Mex.	1915	......	......	......	126,663	......
Dome	Ont.	'14–'15	248,550	315,179	......	2,782,811	2.97*
Ducktown Sulphur and Copper	U.S.	1914	169,000	......	£199,820	3,240,000	......
Durban-Roodepoort	Tran.	1914	170,238	£36,341	£31,500	475,093	3.99*
Durban-Roodepoort Deep	Tran.	1914	299,090	£57,237	£33,000	1,303,400	5.69*
East Butte	U.S.	1915	150,911	782,988	......	......	......
East Rand Proprietary	Tran.	1914	1,831,950	£736,157*	£428,032	5,400,000	4.70*
Elkton Con	U.S.	1915	36,103	32,968	100,000	......	......
El Paso	U.S.	1915	34,442	37,443	......	19,000	......
Esperanza	Mex.	1914	120,975	319,967	157,500	200,000 tails	......
						148,365	5.95
Falcon Mines	Rhod.	'14–'15	130,567	£71,174	......	874,029	9.52
Federal Min. & Smelt.	U.S.	1915	437,686	310,363	479,443	1,107,600	6.45
Gaika Gold	Rhod.	'14–'15	37,514	£34,436	£41,024	95,570	6.87
Geduld	Tran.	1914	244,385	£96,968	£46,125	1,900,000	5.93*
Geldenhuis Deep	Tran.	1914	570,600	£129,096	£109,878	1,613,000	5.55*
Giant	Rhod.	'14–'15	57,086	£1,298	......	113,982	3.73
Globe & Phoenix	Rhod.	1914	......	......	£240,000	194,400	......
Goldfield Consol	U.S.	1915	390,054	1,555,308	1,601,617	105,000	5.02
Gold Hunter	U.S.	1915	118,764	31,662	......	......	4.91
Gold Roads	U.S.	1914	107,846	......	......	......	......
Great Boulder Perseverance	Aus.	1914	245,555	£27,996	......	595,007	4.61
Great Boulder Proprietary	Aus.	1914	190,117	£300,632	£262,000	560,647	6.77
Great Fingall	Aus.	1914	44,006	—£25,821	......	63,360	10.95
Greene Cananea	Mex.	1914	384,690	615,792	1,000,000	......	8.41
Grenville	Eng.	½–1914	21,483	£1,869	......	......	6.50
		2/2–1914	24,515	......	......	......	......
Hecla	U.S.	1915	123,986	561,752	565,000	1,100,000	3.84
Hedley Gold	B.C.	1915	74,265	374,746	300,000	423,522	5.68
Hollinger	Ont.	1914	208,936	1,786,679	1,170,000	......	4.50
Homestake	U.S.	1915	1,573,822	2,345,545	2,210,208	......	2.66
Hornsilver	U.S.	1915	30,057	74,710	......	......	3.03
Hutti Gold Mines	Ind.	1914	33,425	£11,081	£9,783	64,000	10.10
Independence (Stratton's)	U.S.	'13–'14	......	72,000	29,820	......	......
Inspiration Con	U.S.	1915	778,851	600,062	......	97,143,000	1.98
Interstate-Callahan	U.S.	1915	113,795	2,921,487	......	......	14.32
Iron Blossom	U.S.	1914	40,480	306,150	400,000	......	14.67
Iron Silver	U.S.	1914	52,490	174,629	100,000	......	......
Isle Royale	U.S.	1915	680,270	498,277	......	......	2.05
Ivanhoe	Aus.	1915	238,514	£115,984	£105,000	1,026,801	5.24
Jim Butler-Tonopah	U.S.	1915	48,146	......	171,802	40,310	10.40
Jumbo Extension	U.S.	'14–'15	16,420	339,373	125,317	86,750	18.97
Kalgurli	Aus.	'13–'14	127,820	£101,330	£96,000	200,000	4.69
Kerr Lake	Ont.	1915	23,035	550,775	620,000	54,830	......
Knights Central	Tran.	1914	284,960	£42,752	......	430,500	4.64*
Knights Deep	Rand.	'14–'15	1,172,920	£152,341	£92,940	2,627,000	3.02
Lake View & Star	Aus.	'14–'15	218,124	£37,136*	£32,000	426,301	$4.80*
Langlaagte Estate	Tran.	1914	589,619	£156,054	......	886,396	4.62
La Rose	Ont.	1915	......	230,662	299,725	......	......
Le Roi No. 2	B.C.	'13–'14	26,679	£6,193	......	......	......
Lena Goldfields	Sib.	'13–'14	......	£50,558	£57,914	......	7.41
Liberty Bell	U.S.	1913	179,178	......	......	......	3.95
Lonely Reef	Rhod.	1914	61,590	£48,005	£50,023	140,042	11.21
Luipardsolei	Rand	'14–'15	218,453	£2,878	......	......	4.76
Magma	U.S.	1915	55,463	611,729	240,000	100,000	7.41
Main Reef West	Tran.	'14–'15	269,770	£50,876	......	416,280	4.82
Mammoth	U.S.	1914	235,146	......	......	......	......
Mason & Barry	Spain	1914	259,238	......	£27,775	......	......
Mason Valley	U.S.	1914	75,038	40,274	......	......	......
Mass Copper	U.S.	1915	323,335	167,473	......	......	2.12
Messini Develop	Tran.	'14–'15	91,033	£130,526	......	131,700	10.42
Mexico Mines of El Oro	Mex.	'14–'15	30,825	£15,597	......	505,300	10.89
Miami	U.S.	1914	1,096,633	......	......	36,500,000	2.87
Miami Copper	U.S.	1915	1,348,122	3,408,562	1,681,004	35,140,000	1.88
Moctezuma	Mex.	1915	424,027	......	......	2,912,830	......
Modderfontein B	Tran.	1914	440,100	£402,000	£385,000	2,772,500	......
Mohawk	U.S.	1915	829,789	1,511,575	600,000	......	1.43
Montana-Tonopah	U.S.	'14–'15	63,754	......	......	......	......
Mount Boppy	Aus.	1914	70,059	£35,416	£14,325	199,559	......
Mount Elliott	Aus.	'13–'14	37,875	259,000	178,000	533,750	......
Mt. Lyell	Tas.	½–1914	163,596	£61,954	£80,424	3,122,723	7.00
Mt. Morgan	Aus.	'13–'14	303,428	£199,054	£200,000	3,125,000	11.94
Mysore	Ind.	1914	304,375	£379,725	£350,750	1,014,000	7.98
Namaqua Copper	Cap.Col.	1914	35,021	£30,070	£23,582	80,875	......

Name of Mine.	Location.	Year.	Tonnage Produced.	Profit.	Dividends.	Ore Reserves, Tons.	Cost per Ton.
Nevada Con. Copper	U.S.	1915	3,081,520	5,905,602	2,999,155	50,525,289	1.67
Nevada Wonder	U.S.	'14–'15	58,124	327,557	140,807	6,224	7.45
New Goch	Tran.	1914	359,850	£124,580	....	825,896	3.22*
New Heriot	Tran.	1914	154,228	£120,32*	£74,750	588,315	5.08*
New Idria	U.S.	1915	66,538	159,028	150,000	....	5.21
N. Y. & Honduras Rosario	Hond.	1914	109,170	....	329,814	418,978	8.34
New Kleinfontein	Tran.	1914	601,000	£272,942	£115,154	2,890,731	4.27*
New Modderfontein	Rand	'14–'15	611,800	£590,487	£437,500	5,179,000	8.19
Nigel	Tran.	1914	141,400	£30,351	£16,732	150,400	6.25
Nipissing	Ont.	1915	77,904	1,441,428	1,200,000	182,748	10.02
North Butte	U.S.	1915	378,105	1,127,646	387,000	....	8.01
North Star	U.S.	1915	109,860	459,906	250,000	....	5.74
Nourse Deep	Tran.	'13–'14	539,800	£160,879	£155,216	2,443,700	5.42
Nundydroog	Ind.	1914	89,950	£97,818	£99,050	164,800	11.12
Old Dominion	U.S.	1915	....	1,337,086	810,000	....	....
Ooregum	Ind.	1914	154,898	£149,272	£138,270	266,260	6.83
Oriental Con.	Korea	'14–'15	297,889	660,096	858,780	746,740	3.23
Oroyo-Links	Aus.	1914	145,130	£14,416	£14,375	160,111	4.76
Osceola	U.S.	1915	1,361,089	1,610,860	1,057,650	....	1.45
Otavi	W.Af.	'13–'14	50,070	....	....	....	....
Ouro Preto	Braz.	1914	80,138	....	....	112,678	....
Phelps Dodge	U.S.-Mex.	1915	1,583,364	9,720,475	9,000,000	....	....
Plymouth Con	U.S.	1914	44,770	£221	....	....	3.17
Plymouth Con	U.S.	1915	129,503	188,000	173,000	....	3.00
Poderosa	Chile	1914	5,206	£28,511	....	2,740	....
Porcupine Crown	Ont.	1915	41,326	297,853	240,000	....	7.68
Portland	U.S.	1915	426,586	798,460	260,000	....	....
Prestea Block A	W.Af.	1914	270,732	....	....	554,137	6.82
Progress	N.Z.	1914	33,150	—£7,708	....	80,000	....
Quincy	U.S.	1915	....	1,873,674	880,000	....	....
Randfontein Central	Tran.	1914	686,330	£698,493	....	2,493,924	4.27
Ray Con	U.S.	1915	2,854,314	$4,589,142	$1,872,319	71,911,475	$2.00*
Rio Tinto	Spain	1915	....	£1,129,821	£1,112,500	....	....
Robinson Deep	Rand	'14–'15	585,730	£277,213	£225,000	1,513,000	4.41
Rooiberg Minerals	Tran.	'14–'15	26,333	£29,924	£22,500	14,714	10.36
Rose Deep	Tran.	1914	48,230	44,931	....	....	5.06.
Santa Gertrudis	Mex.	1915	211,669	£44,781	£75,000	1,287,000	4.71
Selukive	Rhod.	'14–'15	17,125	£2,056	£9,350	26,106	....
Seoul Mining	Chosen	1915	108,078	....	250,000	1,221,331	3.94*
Shattuck-Arizona	U.S.	1915	102,391	1,174,028	875,000	....	....
Shela Gold	Tran.	'14–'15	84,910	£27,638	£26,973	....	6.63
Silver King Con.	U.S.	'15–'16	13,719	....	255,032	....	....
Simmer & Jack Prop.	Rand	'14–'15	808,300	£334,556	£300,000	....	3.20
Simmer Deep	Tran.	1914	643,000	£39,037	....	1,429,000	3.75*
Sons of Gwalia	Aus.	1914	160,963	£42,148	£48,750	....	6.29
South Crofty	Eng.	1914	69,342	£2,653	£4,375	....	5.00
South Eureka	U.S.	1'5–'16	145,124	125,924	125,354	....	3.09
South Kalgurli	Aus.	1914	116,179	£9,634	....	165,146	5.35
Spassky Copper	Sib.	1914	20,697	£115,502	£97,894	524,400	....
St. John del Rey	Braz.	'14–'15	191,500	£144,092	£64,626	....	7.92
St. Joseph Lead Co.	U.S.	1915	2,127,333	4,283,425	854,980	....	....
Sudan Goldfield	S.Af.	1914	16,456	£20,000	....	....	....
Sulphide Corporation	Aus.	'14–'15	197,180	....	....	2,039,000	....
Superior & Boston	U.S.	'13–'14	25,625	—15,982	....	....	....
Superior & Pittsburg	U.S.	1914	485,796	....	....	....	....
Talisman, Con.	N.Z.	'13–'14	41,680	....	£120,750	37,515	13.78
Tamarack	U.S.	1915	217,027	78,988	....	....	3.06
Temiskaming	Ont.	1915	26,927	96,585	75,000	....	....
Tennessee Copper	U.S.	1915	511,940	1,242,693	600,000	5,087,421	2.83
Tharsis Sulph. & Copper	Spain	1914	501,037	....	£156,250	....	....
Tomboy	U.S.	'14–'15	145,857	396,223	226,000	535,000	4.49
Tom Reed	U.S.	'13–'14	48,100	....	....	....	8.66
Tonopah Belmont	U.S.	'15–'16	165,157	1,001,028	750,016	142,164	6.85
Tonopah Extension	U.S.	'14–'15	71,882	596,891	283,026	12,651	9.40
Tonopah Mining	U.S.	'15–'16	136,197	....	....	53,493	7.78
Trimountain	U.S.	1915	349,684	654,747	....	....	2.26
Tronoh	Malay.	1914	442,394†	—£20,109	....	....	1.75
United Glok Mines	U.S.	1915	141,240	806,743	621,000	....	....
U.S.S.R. & M. Co.	U.S.-Mex.	1915	1,066,025	6,592,524	1,965,561	....	....
Utah Apex	U.S.	'13–'14	121,675	54,561	....	....	....
Utah Consolidated	U.S.	1915	272,248	1,128,122	600,000	310,200	....
Utah Copper	U.S.	1915	8,494,300	17,913,481	1,904,082	270,000,000	....
Van Roi	B.C.	'13–'14	16,025	—£3,835	....	....	7.09
Van Ryn	Tran.	1915	462,820	£235,697	£225,000	1,973,000	3.62
Village Deep	Tran.	1914	600,250	£289,062	£225,392	2,853,470	4.45

Name of Mine.	Location.	Year.	Tonnage Produced.	Profit.	Dividends.	Ore Reserves, Tons.	Cost per Ton.
Victoria	U.S.	1915	133,984	....	....	....	1.85
Vindicator	U.S.	1915	218,487	1,350,164	225,000	2,000,000	......
Waihi	N.Z.	1914	183,405	£145,016	£99,181	753,358	6.22*
Waihi Grand Jc	N.Z.	1914	185,720	£76,636	£57,656	173,000	6.34
Wallaroo & Moonta	Aus.	1915	67,470	£168,085	£60,000	....	......
Wanderer	Tran.	'13–'14	150,060	£1,789	....	102,300	2.42
Wasp No. 2	U.S.	1914	176,140	45,465	30,000	....	1.29
West Rand Cons	Tran.	1914	310,750	....	....	....	5.89
Winona	U.S.	1915	102,594	....	....	....	2.90
Witwatersrand Deep	Tran.	1914	518,409	£251,168	£178,750	1,707,400	3.99*
Witwatersrand Gold	Tran.	1914	503,350	£271,023	£234,812	1,221,879	3.24
Wolhuter	Tran.	'13–'14	382,700	£53,853	£107,500	999,400	4.47*
Wolverine	U.S.	'13–'14	182,127	81,075	....	....	2.21
Yuanmi	Aus.	'13–'14	50,094	....	....	....	4.71
Yukon Gold	U.S.	1915	12,817,804	2,121,001	1,050,000	....	......
Zinc Corporation	Aus.	1914	144,667	£129,398	L49,139	1,185,870	......

* Working cost. † Cu. yd. — Loss for year.

AUSTRALASIA

In the following tables the production of minerals and metals in each of the Australian states and New Zealand is separately itemized. In the tables relating to foreign commerce, however, the states are not separately treated, the combined statistics of the Commonwealth now being officially reported. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF NEW SOUTH WALES (*a*)
(In metric tons or dollars; £1 = $5) (*b*)

Year.	Alunite.	Antimony and Ore.	Bismuth Ore.	Chrome Ore.	Coal.	Coke.	Cobalt Ore.	Copper Ore.
1900.....	1,946	252	11	3,338	5,595,879	128,238	145	867
1901.....	3,196	90	21	2,523	6,063,921	130,944	112	655
1902.....	3,702	58	10	508	6,037,083	128,902	35	3,190
1903.....	2,524	13	23	1,982	6,456,523	163,161	155	1,750
1904.....	376	111	41	404	6,116,126	173,742	6	2,470
1905.....	2,745	394	56	53	6,738,252	165,568	*Nil.*	487
1906.....	1,886	2,490	25	15	7,748,384	189,038	*Nil.*	(*g*)
1907.....	2,021	1,780	17	30	8,796,451	258,683	*Nil.*	(*g*)
1908.....	1,099	119	9	*Nil.*	9,293,377	288,413	*Nil.*	(*g*)
1909.....	3,556	97	9	*Nil.*	7,132,548	207,553	*Nil.*	(*g*)
1910.....	1,154	99	7	*Nil.*	8,304,693	286,854	10	(*g*)
1911.....	1,023	168	9	*Nil.*	8,831,175	268,935	*Nil.*	(*g*)
1912.....	3,479	64	6	*Nil.*	10,044,487	245,050	*Nil.*	(*g*)
1913.....	2,269	18	9	*Nil.*	10,587,734	303,585	*Nil.*	(*g*)
1914.....	3,089	37	15	*Nil.*	10,556,872	309,677	*Nil.*	(*g*)

Year.	Copper Matte, Ingot, and Regulus.	Diamonds. *Carats.*	Gold. (*b*)	Lead, Argentiferous. (*f*)		Lead, Pig. (*f*)	Molybdenite.	Opal.
				Ore.	Metal. (*e*)			
1900....	6,243	9,828	$5,211,097	426,480	19,400	(*d*)6,807	....	$400,000
1901....	6,184	9,322	3,587,040	406,560	17,191	(*d*)3,394	....	600,000
1902....	5,560	11,995	3,333,064	371,496	15,660	(*d*)4,685	16	700,000
1903....	8,094	12,239	5,255,421	335,870	18,779	(*d*)3,561	31	500,000
1904....	6,654	14,296	5,576,966	373,362	30,212	(*d*)5,977	26	285,000
1905....	7,899	6,354	5,669,099	420,266	28,244	214	20	295,000
1906....	9,911	2,827	5,249,762	377,890	22,573	60	34	282,500
1907....	10,260	2,539	5,112,852	441,024	20,687	20,084	22	395,000
1908....	9,215	2,205	4,646,451	364,488	(*h*)	15,174	9	209,000
1909....	7,078	5,474	4,231,211	273,628	(*h*)	15,724	29	309,000
1910....	13,096	3,606	4,011,055	322,780	(*h*)	21,534	50	331,000
1911....	12,295	5,771	3,743,672	343,902	(*h*)	17,552	21	286,500
1912....	11,211	2,239	3,416,560	350,850	(*h*)	17,528	57	170,349
1913....	9,619	5,573	3,093,331	397,783	(*h*)	23,947	80	143,513
1914....	6.713	1,580	2,583,496	342,411	(*h*)	26,405	62	132,670

Year.	Platinum. Kg.	Oil Shale.	Silver. Kg. (f)	Tin.		Tungsten Ore.	Zinc. (c) (f)
				Ore.	Block.		
1900......	15.6	23,229	24,080	15	1,087	....	20,594
1901......	12.1	55,650	13,950	11	659	....	642
1902......	11.6	63,886	33,195	23	502	....	1,281
1903......	16.5	35,332	34,195	556	949	9	21,086
1904......	16.6	38,477	34,880	586	1,084	106	58,523
1905......	12.4	38,838	12,987	726	817	228	105,189
1906......	6.4	32,965	8,865	(h)	1,698	245	105,325
1907......	8.6	48,088	63,573	(h)	1,945	409	241,015
1908......	4.2	47,044	77,490	(h)	1,822	247	281,147
1909......	13.7	49,500	53,430	(h)	1,974	129	379,907
1910......	10.3	69,385	55,176	(h)	1,898	168	476,125
1911......	14.6	76,306	54,975	(h)	1,960	288	524,666
1912......	19.0	87,399	74,314	(h)	2,107	231	528,872
1913......	13.7	17,268	68,267	(h)	3,071	172	515,105
1914......	6.9	50,880	81,408	(h)	2,355	200	365,059

(a) From the Annual Report of the Department of Mines, New South Wales. (b) Where gold is reported, £1 = $4.866. (c) Spelter and concentrate. (d) Includes minor quantities of lead carbonate and chloride, the product of the leaching plant at Broken Hill. (e) Includes a small quantity of silver-sulphide. (f) Exported. In the case of lead, 101,811 long tons was produced in 1912 from N. S. Wales in Australia; see article on lead. (g) Included with metal. (h) Included with ore.

MINERAL PRODUCTION OF QUEENSLAND (a)
(In metric tons or dollars; £1 = $5)

Year.	Bismuth Ore.	Coal.	Copper.	Gold. (b)	Lead.	Manganese Ore.
1901......	20	548,104	3,110	$12,367,276	570	221
1902......	1	509,579	3,845	13,238,500	271	4,674
1903......	11	515,950	4,995	13,818,653	3,856	1,341
1904......	20	520,232	4,440	13,210,869	2,079	843
1905......	15	537,795	7,337	12,249,157	2,464	1,541
1906......	7	610,480	10,238	11,257,316	2,854	1,131
1907......	6	694,204	12,959	9,641,789	5,240	1,134
1908......	22	707,473	14,932	9,613,051	7,207	1,403
1909......	11	768,720	14,727	9,416,576	5,323	613
1910......	22	885,108	16,649	9,123,531	2,435	805
1911......	10	905,568	20,709	7,981,791	1,799	1,167
1912......	(c) 201	917,202	23,505	7,191,846	3,179	313
1913......	(c) 185	1,045,243	24,050	5,492,585	3,663	27
1914......	(c) 197	1,071,237	18,738	5,156,919	736	6
1915......	(c) 253	1,041,003	20,025	5,161,381	494	203

Year.	Molybdenite.	Opal.	Silver. Kg.	Tin Ore.	Tungsten Ore.
1901...........	....	$37,000	17,777	1,638	73
1902...........	(c) 42	35,000	21,813	2,118	56
1903...........	(c) 24	36,500	19,972	3,768	200
1904...........	(c) 22	17,750	20,370	3,986	1,564
1905...........	64	15,000	18,716	4,008	1,434
1906...........	108	15,000	24,357	4,900	785
1907...........	68	15,000	28,662	5,222	627
1908...........	89	12,500	36,200	4,903	426
1909...........	94	10,000	31,140	3,379	617
1910...........	108	15,000	26,787	3,000	869
1911...........	(c)232	15,000	17,076	3,140	548
1912	104	14,600	17,712	3,284	636
1913...........	68	14,600	18,817	4,251	364
1914...........	79	9,700	7,899	2,119	245
1915..	99	2,500	7,457	2,160	425

(a) From *Annual Reports* of the Under Secretary of Mines, Queensland. (b) Where gold is reported, £1 = $4.866. (c) Includes bismuth and some tungsten.

MINERAL PRODUCTION OF SOUTH AUSTRALIA
(In metric tons or dollars) (*a*)

Year.	Copper.		Gold. (*b*)	Iron Ore.	Lead.	Lime-stone.	Phosphate Rock.	Salt.	Other Metals and Minerals.
	Ore.	Metal.							
1902.....	2,620	6,956	$121,056	....	2,210	....	....	....	$3,710
1903.....	7,182	6,594	139,411	86,291	732	....	1,016	40,640	500
1904.....	3,100	6,378	369,938	47,434	....	44,135	3,048	40,640	990
1905.....	2,604	6,653	223,121	85,835	53	45,210	5,080	33,020	6,305
1906.....	535	8,339	131,382	76,430	51	32,451	5,944	55,880	11,045
1907.....	....	8,058	99,948	85,954	....	31,598	8,128	76,200	12,500
1908.....	....	5,718	59,852	89,412	....	29,973	11,177	76,204	22,500
1909.....	1,250	5,788	146,982	16,379	142	13,986	3,833	52,232	19,365
1910.....	....	5,184	136,248	46,939	406	18,898	5,283	54,862	68,000
1911 (*a*)..	....	6,017	72,990	42,976	....	29,159	5,893	66,040	56,600
1912.....	....	6,395	136,248	42,877	....	51,412	6,198	65,338	51,044
1913.....	....	7,174	134,275	61,669	....	45,038	6,049	66,083	104,906
1914.....	....	6,996	129,343	43,324	....	54,955	6,184	66,083	179,425
1915.....	....	7,851	125,689	241,252	....	72,895	4,689	65,066	207,140

(*a*) From *Review of Mining Operations*, by Hon. Richard Butler, Adelaide, 1911. (*b*) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF TASMANIA (*a*)
(In metric tons or dollars) (*b*)

Year.	Coal.	Copper Ore.	Blister Copper.	Gold. (*b*)	Iron Ore.	Lead-Silver Ore.	Tin Ore.
1902.......	49,647	8,630	7,869	$1,467,454	2,424	47,226	1,989
1903.......	49,856	3,891	6,791	1,237,925	6,076	43,103	2,414
1904.......	62,090	(*d*)	8,826	1,362,587	6,950	51,959	2,104
1905.......	52,825	(*d*)	9,919	1,520,101	6,401	76,424	3,953
1906.......	53,742	2,270	8,847	1,240,650	2,642	88,513	4,545
1907.......	59,833	1,261	8,378	1,350,836	3,048	91,216	4,412
1908.......	62,044	1,204	8,974	1,179,950	3,657	62,022	4,593
1909.......	67,224	1,613	8,472	951,005	*Nil.*	81,668	4,583
1910.......	83,763	682	8,324	765,784	*Nil.*	52,047	3,760
1911.......	57,980	2,323	6,118	628,375	*Nil.*	62,489	4,016
1912.......	54,366	1,414	5,218	784,320	*Nil.*	91,570	3,773
1913.......	55,960	2,000	4,645	690,369	*Nil.*	84,677	4,077
1914.......	61,807	3,343	7,634	542,437	*Nil.*	11,758	2,616
1915.......	65,612	67	8,031	383,450	(*e*)13,049	10,556	2,642

(*a*) From *Statistics of the Colony of Tasmania*. (*b*) Where value of gold is reported. £1 = $4.866. (*c*) Included with lead-silver ore. (*d*) Not reported. (*e*) Iron pyrite.

MINERAL PRODUCTION OF NEW ZEALAND (*a*) (*b*)
(In metric tons or dollars) (*c*)

Year.	Anti-mony.	Chrome Ore.	Coal.	Coke.	Copper Ore.	Gold. (*c*)	Kauri-gum.	Manga-nese Ore.	Silver. *Kg.*
1903...	....	....	1,442,987	......	6	$9,916,086	9,507	71	28,364.3
1904...	....	....	1,562,520	......	....	9,671,180	9,203	196	34,042.3
1905...	....	....	1,611,207	15	4	10,189,093	10,883	55	36,695.0
1906...	....	....	1,757,284	5	....	11,050,219	9,300	16	43,251.5
1907...	100	....	1,860,397	15	57	9,865,766	8,847	5	48,603.5
1908...	5	....	1,890,844	2	13	9,755,303	5,618	*Nil.*	53,834.8
1909...	2	*Nil.*	1,941,923	23	5	9,765,575	8,382	6	56,410.0
1910...	*Nil.*	*Nil.*	2,232,610	*Nil.*	*Nil.*	9,227,532	8,832	5	52,176.8
1911...	20	*Nil.*	2,099,234	*Nil.*	*Nil.*	9,105,000	7,587	1	40,775.2
1912...	....	....	2,177,615	4	*Nil.*	6,427,422	7,908	....	24,237.8
1913...	....	....	1,919,472	28	....	7,101,822	8,926	....	30,344.6
1914...	....	....	2,313,519	17	3	4,356,856	8,581	....	18,636.4
1915...	....	....	2,244,700	......	....	8,245,695	4,650	....	29,783.6

(*a*) From New Zealand Mines Statement, by the Hon. Roderick McKenzie, Minister of Mines, Wellington. (*b*) The exports are stated to be identical with the production, with the exception of coal. (*c*) Where gold is reported, £1 = $4.866.

MINERAL PRODUCTION OF VICTORIA (*a*)
(In metric tons or dollars)

Year.	Antimony Ore	Coal.	Lignite.	Gold. (*c*)	Building Stone, etc. (*b*)	Tin Ore.
1901.......	*Nil.*	212,678	152	$16,320,029	$225,000	78
1902.......	*Nil.*	228,777	(*b*)	14,899,876	266,975	10
1903.......	5	65,230	5,752	15,860,815	213,245	34
1904.......	20	123,695	*Nil.*	15,824,952	1,496,110	72
1905.......	25	157,648	*Nil.*	15,443,438	1,560,090	126
1906.......	208	163,201	*Nil.*	15,962,804	1,705,420	108
1907.......	4,575	140,802	*Nil.*	14,377,166	2,023,130	105
1908......	3,740	115,283	*Nil.*	13,867,312	2,138,070	80
1909.......	1,779	130,230	*Nil.*	13,522,400	2,226,220	90
1910.......	1,283	374,775	660	11,789,077	2,542,815	42
1911.......	1,116	664,326	6,232	11,789,077	2,820,800	33
1912.......	2,470	598,599	4,076	9,924,032	3,385,070	48
1913.......	6,253	603,811	3,034	9,189,593	3,261,815	58
1914.......	7,730	627,828	2,760	8,540,978	3,485,880	54
1915.......	11,113	588,104	2,864	6,794,771	....	96

(*a*) From Annual Reports of the Secretary for Mines of the Colony. (*b*) Includes bricks, tiles, pottery and salt. (*c*) Where gold is reported, £1 = $4.866. (*e*) Estimated value.

MINERAL PRODUCTION OF WESTERN AUSTRALIA (*a*)
(In metric tons or dollars)

Year.	Tungsten Ore.	Coal.	Copper Ore.	Copper and Matte.	Gold. (*b*)	Iron Ore.	Lead Ore.	Silver. *Kg.*	Tin Ore.
1905.....	....	129,402	2,389	....	$ 38,045,366	3,264	*Nil.*	11,189	1,096
1906.....	....	152,151	7,548	(*f*)3,676	35,888,278	1,300	*Nil.*	8,776	1,511
1907.....	....	144,651	19,282	1,628	35,087,500	1,112	(*d*) 214	5,887	(*e*) 1,529
1908.....	....	178,061	8,427	486	34,061,426	*Nil.*	(*d*) 526	5,240	(*e*) 1,118
1909.....	1	217,741	7,071	846	32,973,349	*Nil.*	(*d*) 214	5,500	(*e*) 703
1910.....	2	266,361	6,410	1,301	30,397,162	10	252	5,478	509
1911.....	10	253,900	9,974	832	28,331,272	*Nil.*	1,575	5,215	502
1912.....	*Nil.*	299,815	9,689	28	26,511,841	*Nil.*	1,898	5,144	666
1913.....	(*g*)1	319,048	(*g*)4,411	(*g*)83	27,160,557	*Nil.*	(*g*)3,222	5,848	(*h*)496
1914.....	(*g*)0.5	324,530	(*g*)3,978	(*g*)186	25,484,960	*Nil.*	(*g*)3,613	6,104.	(*gh*)368
1915.....	(*g*)0.3	291,444	(*g*)749	(*g*)1,063	25,012,349	*Nil.*	(*g*)2,931	6,909	(*gh*)436

(*a*) From the *Report of the Department of Mines of Western Australia.* (*b*) £1 = $4.866 (*d*) Silver-lead and lead ore. (*e*) Includes ingots. (*f*) Total in previous years. (*g*) Exports (*h*) Ore and ingot.

MINERAL IMPORTS OF AUSTRALIA (*a*)
(In metric tons, cwt. of 112 lb., or dollars; £1 = $5) (*b*)

Year.	Cement. *Cwt.*	Coal.	Coke.	Copper Ore. *Cwt.*	Gold. (*b*)				
					Ore.	Bullion.	Specie.	Foil. (*c*)	Total Value.
1905	700,245	7,866	5,553	80	$103,709	$7,067,534	$122,127	$52,144	$7,645,514
1906	793,928	15,816	6,202	873	93,116	10,053,463	397,990	53,356	10,597,925
1907	513,326	14,973	9,981	3,652	136,520	6,942,940	48,499	45,283	7,173,245
1908	915,033	14,833	10,368	3,959	42,855	4,625,498	70,197	....	4,738,550
1909	848,337	16,144	44,668	4,533	35,687	4,865,436	56,280	118,240	5,075,643
1910	1,612,004	314,393	17,161	23,027	35,712	4,653,044	126,556	....	4,815,312
1911	1,670,117	10,498	22,608	10,201	62,951	7,707,919	124,248	....	7,895,118
1912	2,603,792	16,152	15,839	18,449	93,885	5,478,177	1,190,890	....	6,762,952
1913	2,511,828	4,928	27,304	25,085	118,263	5,699,945	910,064	201,645	6,929,917
1914(*e*)	1,040,494	14,085	10,887	11,736	71,311	2,670,213	973,200	....	3,714,724
1915(*f*)	1,407,099	13,580	15,852	14,037	112,035	2,105,421	16,773	....	2,234,229

Year.	Graphite. *Cwt.*	Iron and Steel.			Lead Mfrs. *Cwt.*	Petroleum Products.		
		Bars, Rods Girders, Sheets, etc. *Cwt.*	Galvanized Plates and Sheets. *Cwt.*	Pig and Scrap. *Cwt.*		Kerosene. *Gal.*	Benzine, Gasoline, etc. *Gal.*	Paraffin.
1905..	4,386	1,482,334	1,112,467	940,757	5,071	16,416,734	292,670	1,661
1906..	6,531	1,878,851	1,245,211	1,220,236	3,930	16,106,083	488,961	2,887
1907..	6,991	2,261,694	1,502,790	1,276,566	2,940	19,273,955	683,679	2,757
1908..	£6,705	2,376,017	(*d*)1,253,624	820,834	2,703	17,154,940	782,859	1,560
1909..	£8,965	2,559,798	(*d*)1,658,291	1,178,219	19,338	19,924,622	884,703	2,772
1910..	£9,951	3,663,386	(*d*)2,131,911	1,073,933	9,111	19,660,890	1,339,381	3,963
1911..	£7,782	4,215,986	(*d*)2,177,961	1,574,439	2 120	19,378,540	1,772,840	3,321
1912..	£8,629	4,933,414	(*d*)2,416,367	1,719,585	955	24,292,539	12,294,617	2,832
1913..	£9,785	5,070,590	(*d*)2,196,865	1,535,030	2,075	19,288,122	8,812,771	2,803
1914 (*e*	£5,319	2,377,790	(*d*)1,265,429	833,008	7,676	12,231,752	8,853,386	1,815
1915 (*f*	£8,359	3,236,889	1,676,033	1,352,011	3,820	20,444,196	12,446,797	2,790

Year.	Potassium Nitrate. *Cwt.*	Quick-silver.	Salt. *Cwt.*	Silver. (*b*)			Sulphur. *Cwt.*	Zinc, Bar and Sheet. *Cwt.*
				Ore. *Cwt.*	Bullion. *Kg.*	Specie.		
1905.....	9,010	82.1	492,727	....	3908.1	261,397	177,304	£30,955
1906.....	8,112	78.6	326,042	380	9756.2	684,958	269,704	£35,142
1907.....	8,571	59.5	409,852	2	113.7	1,829,309	264,060	27,346
1908.....	6,036	56.4	390,535	....	189.8	1,019,738	420,098	27,449
1909.....	6,894	58.4	273,442	1,972	622.2	157,352	405,396	58,451
1910.....	7,016	57.6	444,081	14,609	1,411.7	1,615,775	357,332	70,339
1911.....	10,257	42.4	753,849	1,734	1,115.8	1,648,430	386,764	86,362
1912.....	10,127	52.8	468,507	3,836	1,580.3	1,350,870	465,643	61,736
1913.....	10,552	46.0	533,055	10,396	1,180.4	861,500	603,865	41,650
1914(*e*)...	6,349	20.9	139,024	....	622.5	546,481	246,586	21,147
1915(*f*)...	7,500	24.0	382,160	319	586.1	2,062,386	421,947	29,193

(*a*) From Trade and Customs Returns, Commonwealth of Australia. Previous to 1900 each Colony reported its own imports and exports. (*b*) Where gold or silver values are reported, £1 = $4.866. (*c*) Includes silver and other foils. (*d*) Includes ungalvanized corrugated.

MINERAL EXPORTS OF AUSTRALIA (*a*)

(In metric tons, cwt. of 112 lb., or dollars; £1 = $5)

Year.	Alunite. *Cwt.*	Anti-mony Ore. *Cwt.*	Bis-muth Ore. *Cwt.*	Cement. *Cwt.*	Chrome Ore. *Cwt.*	Coal.	Coke.	Co-balt Ore. *Cwt.*	Copper.	
									Ore. (*f*) *Cwt.*	Ingot and Matte. (*Cwt.*)
1905...	54,040	7,811	2,222	40,004	(*c*)	2,058,307	2,306	1,320	17,380	632,193
1906...	37,120	66,288	1,574	80,368	(*c*)	2,094,911	11,382	3	33,476	744,357
1907...	41,750	74,440	653	75,600	54,503	2,690,070	35,063	....	157,071	853,236
1908...	21,640	23,931	1,396	49,116	22,300	2,601,962	28,068	....	103,694	765,298
1909...	73,795	14,976	1,763	23,585	....	1,608,173	24,798	280	162,904	676,664
1910...	23,290	12,796	1,456	34,259	....	1,730,473	10,457	186	260,597	765,176
1911...	20,274	17,985	2,307	45,247	....	1,714,959	8,543	....	264,688	806,005
1912...	68,500	30,894	610	27,724	453	2,186,946	9,852	....	259,690	876,773
1913...	44,700	51,007	588	18,221	....	2,132,201	8,163	....	177,757	846,411
1914(*g*)	24,200	30,661	151	23,813	....	1,182,548	2,636	....	62,658	392,005
1915(*h*)	52,400	50,316	1,295	24,591	....	1,394,151	14,563	....	142,363	669,189

Year.	Gold. (b) Ore.	Bullion.	Specie.	Total Value.	Iron and Steel Bars, Rods, etc. Cwt.	Lead. Pig and Matte. Cwt.	Argentiferous. Cwt.	Manufactures Cwt.
1905....	49,507	25,788,574	27,523,288	53,361,369	169,077	1,278,379	753,008(h)	34,717
1906....	20,296	24,113,950	57,981,723	82,115,969	216,862	1,018,856	781,426(h)	20,407
1907....	17,513	(e) 19,639,502	33,370,240	53,027,255	194,237	1,006,945	767,262	21,765
1908....	20,539	(e) 18,924,716	50,794,544	69,739,799	170,636	1,483,415	648,784	20,161
1909....	270,131	(e) 17,265,872	26,028,555	43,564,558	158,468	808,297	573,072	14,067
1910....	429,288	(e) 12,070,522	16,598,747	23,098,557	154,846	1,326,702	473,556	13,350
1911....	327,107	(e) 10,456,322	47,831,267	58,614,696	116,893	1,358,308	397,342	14,610
1912....	340,474	(e) 9,135,487	50,801,322	60,277,283	138,061	1,438,681	502,264	17,916
1913....	371,257	6,695,757	10,184,007	17,251,021	184,433	1,529,075	524,513	14,989
1914 (g).	45,825	(e) 2,119,722	4,882,690	7,048,235	71,337	676,457	376,587	10,239
1915 (h).	255,883	(e) 3,325,439	9,447,081	13,028,403	179,122	1,427,455	737,416	14,190

Year.	Molybdenum Ore. Cwt.	Salt. Cwt.	Shale. Oil.	Silver. Ore. (d) Cwt.	Bullion. Kg.	Tin. Ore. Cwt.	Block. Cwt.	Zinc, Bar and Sheets. Cwt.
1905.....	1,381	184,260	11,818	581,651	208,467	55,153	108,963	£3,131
1906.....	1,867	208,750	7,702	1,010,707	201,175	51,793	130,120	£4,820
1907.....	2,025	189,194	5,777	907,790	294,673	65,005	131,407	1,769
1908.....	2,116	240,348	19,173	1,137,746	326,249	49,409	121.979	307
1909.....	1,055	230,486	3,983	(f) 1,914,479	210,570	(f)57,902	111,262	167
1910.....	1,972	184,892	9,307	(f) 2,520,652	233,494	(f)48,209	87,529	1,807
1911.....	1,876	63,607	6,344	(f) 3,226,043	(e)218,387	(f)55,721	82,935	1,050
1912.....	2,873	123,779	290	(f) 2,395,267	(e)238,947	(f)64,704	77,501	15,971
1913.....	2,684	134,863	449	(d)(f)3,377,901	(e)252,219	(f)89,384	68,392	12,236
1914 (g)..	2,009	47,560	283	(df)1,701,932	(e)126,139	(f)42,616	27,624	....
1915 (h)..	2,080	111,001	457	(df) 553,173	(e)213,102	(f)42,845	29,891	54,099

(a) From Trade and Customs Returns, Commonwealth of Australia.—Note. Previous to 1900 each Colony reported its own exports separately. (b) Where gold or silver values are reported, £1 = $4.866. (c) Included with iron ore. (d) Includes lead ore. (e) Includes that contained in matte. (f) Includes concentrates.

AUSTRIA-HUNGARY

In the following tables the mineral and metal productions of the two Kingdoms are reported separately, together with that of Bosnia and Herzegovina. Exports and imports are reported jointly.

MINERAL AND METALLURGICAL PRODUCTION OF AUSTRIA (*a*)
(In metric tons)

Year.	Alum.	Alum and Pyritic Shale.	Antimony.		Asphalt and Asphaltic Rock.	Bismuth Ore.	Coal.	
			Ore.	Metal.			Bituminous.	Lignitic.
1900.......	620	3,004	201	153	924	4.0	10,992,515	21,539,917
1901.......	442	2,551	126	114	561	16.0	11,738,840	22,473,510
1902.......	62	2,866	18	24	927	8.0	11,045,039	22,139,683
1903.......	*Nil*	2,978	41	14	1,298	9.7	11,498,111	22,157,521
1904.......	*Nil*	2,337	103	36	1,435	1.7	11,868,245	21,987,651
1905.......	*Nil*	1,657	1,673	90	4,363	1.7	12,585,263	22,692,076
1906.......	*Nil*	1,020	1,071	*Nil*	2,840	2.7	13,473,307	24,167,714
1907.......	*Nil*	*Nil*	910	207	3,858	*Nil*	13,850,420	26,262,110
1908.......	*Nil*	*Nil*	193	162	3,695	*Nil*	13,875,382	26,728,926
1909.......	*Nil*	*Nil*	450	*Nil*	2,975	*Nil*	13,713,043	26,043,716
1910.......	*Nil*	*Nil*	225	*Nil*	1,066	*Nil*	13,773,985	25,132,855
1911.......	*Nil*	*Nil*	270	....	1,740	....	14,379,817	25,265,334
1912.......	....	....	4,520	13	4,234	....	15,797,890	26,283,690
1913.......	....	....	1,270	....	3,026	....	16,459,889	27,378,332

Year.	Copper.			Copperas.	Gold.		Graphite.	Iron.	
	Ore.	Metal.	Sulphate.		Ore.	Bullion.		Ore.	Pig & Cast.
1900.......	5,825	881	234	474	227	$47,183	33,663	1,894,458	1,000,207
1901.......	7,406	776	256	472	143	31,234	29,992	1,963,246	1,030,260
1902.......	8,455	914	248	271	74	4,652	29,527	1,744,498	991,827
1903.......	8,188	961	310	298	2,148	5,316	29,590	1,715,984	970,832
1904.......	10,701	889	808	414	12,653	47,183	28,620	1,719,219	988,364
1905.......	10,677	870	540	116	35,937	133,218	34,416	1,913,782	1,119,614
1906.......	20,255	877	578	154	33,033	83,401	38,117	2,253,662	1,222,230
1907.......	10,400	592	579	*Nil*	30,711	92,471	49,425	2,540,118	1,383,524
1908.......	8,381	683	556	*Nil*	28,907	98,504	44,425	2,632,407	1,466,897
1909.......	11,826	985	591	70	29,709	98,295	40,710	2,490,277	1,465,051
1910.......	8,005	1,468	715	30	31,744	118,895	33,131	2,627,513	1,504,786
1911.......	10,974	1,760	767	*Nil*	29,647	134,840	41,599	2,765,815	1,596,148
1912.......	17,354	3,057	884	40	30,192	134,543	45,375	2,926,686	1,759,850
1913.......	16,353	3,685	897	40	35,994	186,714	49,456	3,039,324	1,757,864

Year.	Lead.			Manganese. Ore.	Mineral Paint.	Petroleum.	Quicksilver.		Salt.
	Ore.	Pig.	Litharge.				Ore.	Metal.	
1900......	14,314	10,650	1,288	8,804	2,828	347,213	94,727	510	330,277
1901......	16,688	10,161	1,317	7,796	1,701	404,662	97,360	525	333,238
1902......	19,055	11,264	1,023	5,646	1,486	520,845	90,040	511	311,806
1903......	22,196	12,162	923	6,179	1,691	672,508	83,321	523	359,015
1904......	22,514	12,645	783	10,189	1,829	823,943	88,279	536	369,877
1905......	23,339	12,968	865	13,788	798	794,391	86,856	520	343,375
1906......	19,683	14,846	1,059	13,402	943	737,194	91,494	526	376,212
1907......	22,792	13,598	863	16,756	1,091	1,725,808	89,370	527	395,053
1908......	21,513	12,669	1,010	16,656	475	1,718,030	90,145	572	388,133
1909......	20,550	12,941	840	18,045	620	2,086,342	92,337	585	359,801
1910......	22,841	15,476	602	15,694	698	1,766,018	100,899	603	345,629
1911......	23,845	18,097	318	15,954	2,902	1,487,842	111,018	704	342,732
1912......	27,952	19,993	301	12,471	2,960	1,144,133	117,780	763	365,789
1913......	25,751	22,312	305	16,540	2,999	1,081,090	130,608	820	337,563

Year.	Silver.		Sulphuric Acid.	Sulphur. Ore.	Tin.		Tungsten Ore.	Uranium.		Zinc.	
	Ore.	Bullion. *Kg.*			Ore.	Block.		Ore.	Salts.	Ore.	Spelter.
1900.	21,641	39,572	7,067	862	51	40	50	52.0	11.3	38,243	6,742
1901.	21,363	40,205	7,073	4,911	42	49	45	48.0	13.0	36,072	7,558
1902.	22,288	39,544	8,781	3,721	47	50	45	46.0	10.0	31,927	8,309
1903.	21,958	39,812	9,105	4,475	57	34	49	45.0	5.8	29,544	8,949
1904.	21,948	39,032	8,742	6,288	77	38	52	17.0	11.4	29,226	9,159
1905.	21,047	38,453	1,007	8,407	52	53	59	16.0	13.9	29,983	9,326
1906.	21,944	38,940	745	15,125	55	42	56	16.0	10.3	32,037	10,804
1907.	22,636	38,742	*Nil*	24,099	53	47	44	11.0	11.2	31,970	11,208
1908.	22,241	39,867	*Nil*	17,429	68	39	37	9.0	8.4	31,266	12,770
1909.	21,102	39,002	*Nil*	12,725	36	52	39	18.0	10.2	33,955	11,688
1910.	23,629	49,692	....	15,839	37	40	40	6.5	10.3	34,637	12,458
1911.	24,143	50,244	....	15,805	944	15	45	5.8	6.8	32,166	15,766
1912.	21,794	49,355	....	13,996	606	13	66	11.0	5.4	34,675	17,298
1913.	19,937	54,434	....	10,561	939	11	52	11.2	4.5	34,225	19,508

(*a*) From the *Statistisches Jahrbuch des K. K. Ackerbau-Ministeriums.*

MINERAL AND METALLURGICAL PRODUCTION OF HUNGARY (*a*)
(In metric tons or dollars; 1 crown = $0.203)

Year.	Antimony.		Asphalt	Asphaltic Rock.	Bismuth.	Carbon Bisulphide.	Coal.			
	Ore.	Regulus.					Bituminous. (*d*)	Lignite. (*d*)	Coke.	Briquets.
1900...	2,373	846	2,700	....	2.0	1,250	1,447,047	5,128,277	12,973	69,353
1901...	(*b*) 323	706	2,878	25,161	1.6	2,087	1,365,270	5,179,829	10,975	40,182
1902...	(*b*) 748	683	2,774	24,873	0.9	2,320	1,162,785	5,132,053	8,204	88,069
1903...	(*b*) 205	732	2,422	21,552	1.5	2,357	1,233,410	5,271,781	9,442	101,197
1904...	1,080	1,007	2,221	17,660	0.9	2,512	1,155,320	5,519,349	5,103	103,481
1905...	949	756	173	19,372	1.4	2,760	919,193	6,015,452	69,303	144,697
1906...	1,807	954	4,111	34,664	2.0	2,756	1,103,529	6,229,712	79,930	151,657
1907...	2,035	841	3,920	33,096	0.4	2,950	1,038,819	6,408,322	97,447	154,783
1908...	1,316	670	4,818	72,972	(*c*)	2,966	982,017	7,034,499	141,954	109,178
1909...	1,971	695	5,054	....	......	3,086	1,397,424	7,658,719	157,415	117,594
1910...	1,939	782	4,994	....	......	3,245	1,302,103	7,734,166	156,048	108,873
1911...	2,616	892	3,861	....	......	3,488	1,290,182	8,154,560	145,104	118,412
1912...	8,380	859	4,460	....	......	3,692	1,302,405	8,287,871	149,913	118,505
1913...	11,017	1,048	3,025	45,860	(*f*)25	3,148	1,319,918	8,954,133	160,073	117,186

Year.	Copper.	Copperas.	Gold.	Iron.			Lead.		Litharge.	Manganese. Ore.
				Ore. (*d*)	Pig.	Cast.	Ore.	Pig.		
1900...	181	700	$2,173,079	1,666,363	432,817	22,738	612	2,030	201	5,746
1901...	162	805	2,189,692	1,557,300	430,686	20,640	(*b*) 10	2,029	238	4,591
1902...	89	909	2,260,135	1,562,238	416,835	18,569	(*b*) 20	2,244	219	7,237
1903...	45	982	2,243,521	1,439,132	396,674	18,875	(*d*)3,698	2,057	257	5,311
1904...	63	1,277	2,437,988	1,524,036	370,297	17,203	(*d*)3,922	2,104	710	11,527
1905...	73	920	2,439,451	1,661,358	403,719	17,563	686	2,146	209	5,708
1906...	69	1,306	2,487,156	1,698,291	402,527	17,164	564	1,925	698	7,176
1907...	85	1,212	2,330,292	(*e*)622,518	423,134	17,103	8	1,468	441	8,198
1908...	166	1,372	2,189,801	(*e*)727,019	505,559	17,415	3	1,544	190	10,601
1909...	265	1,414	1,813,024	1,965,487	514,853	15,577		1,590	625	11,921
1910...	214	1,313	2,022,032	1,905,749	487,421	14,635	91	2,077	570	13,270
1911...	208	849	2,125,241	1,950,231	502,460	15,990	239	1,583	391	14,755
1912...	242	1,364	1,898,771	1,991,162	541,659	11,180	1,212	1,605	477	13,833
1913...	405	627	1,945,958	2,059,076	608,966	13,986	488	1,137	412	19,006

Year.	Mineral Paints.	Petroleum.	Pyrite.	Quicksilver. *Kg.*	Salt.	Silver. *Kg.*	Sulphur.	Sulphuric Acid.	Zinc.	
									Ore.(*b*)	Spelter.
1901...	305	3,296	93,907	33,003	215,581	23,636	137	1,464	693	14
1902...	283	4,347	106,490	44,600	217,079	23,020	105	1,193	364	....
1903...	263	3,010	96,619	43,700	214,536	19,281	135	1,543	46	26
1904...	273	2,134	97,148	45,169	230,943	16,352	143	1,329	203	....
1905...	196	471	106,848	36,000	238,642	15,946	135	1,410	173	....
1906...	221	2,692	112,623	50,100	245,402	13,642	133	1,457	243	146
1907...	259	2,404	99,503	40,400	(*c*)	12,695	(*c*)	1,232	(*c*)	(*c*)
1908...	294	2,427	95,824	78,000	(*c*)	12,612	144	1,444	135	(*c*)
1909...	63	2,590	98,971	71,500	231,182	10,932	131	1,307	(0)	....
1910...	55	2,501	92,464	90,000	230,315	12,547	128	1,334	280	....
1911...	69	2,191	96,755	79,700	239,006	10,806	51	938	106	....
1912...	105	2,793	103,809	84,979	270,929	10,782	83	1,311	778	....
1913...	57	2,105	106,629	88,800	256,448	8,696	42	555	407	....

(*a*) From the *Annuaire Statistique Hongrois*. (*b*) Includes only that part of the crude output that was not smelted into a refined product. (*c*) Not reported. (*d*) Total production. (*e*) Exported. (*f*) Kilograms.

MINERAL AND METALLURGICAL PRODUCTION OF BOSNIA AND HERZEGOVINA (*a*)
(In metric tons)

Year.	Chrome Ore.	Copper.		Iron.		Lignite.	Manganese Ore.	Pyrite.	Quicksilver.	Salt.
		Ore.	Metal.	Ore.	Pig.					
1902...	270	3,657	166	133,348	43,992	424,753	5,760	5,170	7.2	17,348
1903...	147	1,073	191	114,059	39,833	467,962	4,538	6,589	8.1	18,459
1904...	279	640	115	127,297	47,678	483,617	1,114	10,412	8.1	18,021
1905...	186	670	39	122,540	43,074	540,237	4,129	19,045	10.0	(*b*)
1906...	320	765	25	136,513	45,660	594,172	7,651	11,347	5.1	22,671
1907...	310	245	*Nil.*	150,684	48,946	621,179	7,000	7,229	1.2	21,148
1908 (*c*)	315	(*b*)	*Nil.*	150,075	48,900	630,500	6,000	(*b*)	*Nil.*	22,100
1909 (*c*)	310	(*b*)	*Nil.*	145,200	48,850	675,400	5,000	(*b*)	*Nil.*	22,500
1910...	320	(*b*)	*Nil.*	132,720	48,841	706,659	4,000	571	*Nil.*	23,579
1911...	250	(*b*)	*Nil.*	140,283	44,354	769,763	3,600	3,118	*Nil.*	22,591
1912...	200	....	*Nil.*	150,420	53,270	852,920	4,650	6,216	*Nil.*	23,124
1913...	305	....	......	220,131	53,587	841,140	4,700	7,701	....	24,176
1914...	211	....	......	178,830	44,078	806,831	4,120	4,459	....	25,730

(*a*) From *Oestr. Zeit. f. B.-u. H.* (*b*) Not reported. (*c*) Estimated.

MINERAL IMPORTS OF AUSTRIA-HUNGARY (*a*)
(In metric tons or dollars; 5 Crowns = $1)

Year.	Alum.	Aluminium and Alloys.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic. (*b*)	Asbestos.	
				Ore.	Regulus. *Kg.*		Crude. (*c*)	Manufactures.
1900.....	430	154	1,435	46	23,000	320	1,085	1,238
1901.....	413	153	1,882	27	1,500	351	1,678	1,032
1902.....	537	151	2,161	40	18,200	351	2,038	798
1903.....	508	150	2,670	42	87,200	371	3,395	1,221
1904.....	602	231	2,346	64	21,000	384	2,517	1,240
1905.....	774	477	2,775	42	24,700	342	5,962	208
1906(*f*) ..	513	216	2,840	79	38,900	83	7,025	111
1907.....	545	255	3,200	231	89,900	325	5,729	180
1908.....	567	323	2,606	304	128,200	349	9,484	139
1909.....	359	418	1,831	95	80,100	370	12,003	200
1910.....	589	303	1,474	96	121,800	416	11,602	250
1911.....	375	516	1,317	98	124,600	377	16,071	276
1912.....	253	1,224	1,396	91	49,000	24	24,615	338
1913.....	454	589	1,334	....	....	47	17,575	248

Year.	Asphalt.		Barytes.	Borax.		Cement.	Chloride of Lime.	Chrome Ore.
	Crude Rock.	Mastic and Bitumen.		Crude, and Boric Acid.	Refined.			
1900.......	8,301	1,564	5,945	3,056	93	25,747	3,326	2,823
1901.......	5,702	1,106	6,336	1,687	233	23,559	3,326	860
1902.......	5,732	1,273	6,266	2,168	174	18,658	2,596	2,668
1903.......	5,871	1,272	7,057	2,192	150	23,256	2,791	2,121
1904.......	8,211	1,064	6,238	2,752	142	20,259	3,407	1,209
1905.......	8,553	1,139	6,187	3,099	205	21,950	1,847	2,305
1906(*f*).....	13,381	895	9,654	3,519	126	21,833	2,491	1,612
1907.......	9,394	1,637	11,669	3,763	138	23,697	2,534	2,795
1908.......	11,678	1,305	11,241	4,105	158	39,135	2,395	1,837
1909.......	9,113	1,309	13,940	3,240	139	53,262	3,105	2,223
1910.......	15,897	1,101	21,486	5,284	166	81,251	1,885	1,271
1911.......	18,394	1,990	20,501	4,407	193	80,613	3,131	2,217
1912.......	25,111	4,295	21,375	4,286	482	83,630	2,802	4,329
1913.......	24,794	1,011	23,350	5,652	356	61,261	3,097	2,845

Year.	Kaolin and Feldspar.	Coal.		Coke.	Copper.			Copper Sulphate.
		Bituminous.	Lignitic.		Ore.	Bullion and Scrap.	Bars, Sheets, Wire, etc.	
1900......	6,847	6,242,939	67,740	620,776	16	18,970	121	3,516
1901......	7,687	5,827,332	22,253	612,209	112	17,504	83	2,822
1902......	9,085	5,766,377	29,601	547,406	100	18,498	149	2,839
1903......	9,940	5,907,660	30,007	519,281	209	18,701	89	3,526
1904......	10,854	6,190,030	30,001	548,272	1,107	22,532	89	4,508
1905......	13,656	6,418,042	36,000	554,147	1,397	22,652	73	3,791
1906 (*f*)...	13,219	5,942,897	17,464	406,088	267	20,943	481	1,597
1907......	17,961	9,692,645	23,699	677,750	44	26,181	818	3,981
1908......	17,417	9,995,415	30,433	851,099	121	33,270	1,140	8,402
1909......	16,185	10,482,264	38,679	701,281	13	30,606	568	4,129
1910......	17,817	9,864,462	37,867	670,089	49	32,217	926	3,445
1911......	22,828	10,873,799	34,381	702,707	716	37,251	538	6,598
1912......	24,628	11,848,535	34,871	(*h*)915,547	765	45,460	850	16,131
1913......	22,467	13,689,149	33,097	933,669	150	36,451	572	6,937

Year.	Copperas.	Cryolite.	Fluorspar.	Gold. (*d*)		Graphite.	Gypsum.		Hydrochloric Acid.
				Bullion.	Coin.		Crude.	Burned.	
1900.....	343	342	5,649	$1,111,831	$7,230,251	302	1,348	15,462	577
1901.....	269	428	5,774	13,865,103	20,353,592	318	1,405	15,830	576
1902.....	274	447	5,902	14,509,019	15,695,960	221	1,588	16,430	588
1903.....	155	521	5,445	9,825,200	9,817,283	405	1,969	18,655	603
1904.....	238	313	7,061	12,703,740	8,586,394	423	2,384	19,387	459
1905.....	169	220	7,601	1,047,792	9,204,968	735	1,553	21,286	656
1906(*f*)..	186	217	7,795	989,604	5,229,591	854	4,104	10,308	476
1907.....	187	613	8,779	1,106,002	5,755,918	934	5,813	11,981	629
1908.....	74	564	7,359	7,303,982	7,969,538	755	4,993	10,842	924
1909.....	56	556	8,106	36,744,037	8,631,453	660	4,907	10,410	898
1910.....	89	703	8,292	1,399,400	4,485,600	1,124	5,733	20,390	635
1911.....	66	944	9,446	3,163,554	1,902,798	1,173	6,616	16,489	612
1912.....	43	1,053	6,396	667,350	1,516,911	1,834	10,585	24,944	1,115
1913.....	53	635	10,204	5,855,085	3,626,938	1,499	8,696	24,659	975

Year.	Iron.				Lead.				
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.	Ore.	Pig, Alloys, Crude.	Litharge.	Red and Yellow.	White.
1900	233,156	95,530	$4,533,599	10,313	501	7,916	141	354	106
1901	218,476	90,287	4,443,670	10,902	1,270	10,722	189	433	135
1902	197,525	43,314	4,304,818	11,584	1,879	8,706	149	428	221
1903	217,979	47,354	4,508,224	11,025	1,355	9,190	141	423	173
1904	182,515	35,091	4,976,342	9,402	1,436	7,917	146	372	138
1905	228,149	49,383	5,722,976	33,256	247	7,282	101	349	88
1906(*f*)	232,558	57,341	6,153,698	5,085	189	11,732	82	310	75
1907	390,322	151,848	(*g*)29,520	29,268	204	12,547	98	381	126
1908	423,940	224,740	(*g*)45,235	88,396	559	17,116	161	616	201
1909	374,088	147,459	(*g*)48,344	34.025	7,560	20,697	230	599	57
1910	307,190	185,604	51,869	44,277	6,354	17,065	411	574	139
1911	469,552	112,907	53,590	32,687	1,200	17,238	299	622	108
1912	628,867	244,532	64,621	48,137	3,240	16,961	403	448	94
1913	942,312	188,324	....	....	8,055	12,455	402	367	113

Year.	Magnesium Chloride.	Manganese Ore.	Millstones.	Mineral Paints.	Nickel, Old and Crude.	Nickel and Cobalt Ores	Nitric Acid.	Peat and Peat Coke.
1900	2,100	7,016	1,672	4,958	258	406	36	2,664
1901	2,529	6,367	1,595	5,109	277	788	22	2,896
1902	2,621	15,595	1,410	4,831	265	225	90	3,234
1903	3,118	38,529	1,395	4,733	268	385	7	3,097
1904	2,997	35,357	1,282	5,563	402	656	24	2,676
1905	3,495	30,483	1,467	6,018	632	391	14	2,432
1906(*f*)	4,050	33,406	1,176	4,660	773	*Nil.*	12	1,918
1907	5,006	70,067	1,469	6,043	1,192	*Nil.*	12	4,460
1908	5,011	31,023	1,474	5,909	1,521	114	11	6,459
1909	6,095	44,970	1,357	5,773	2,116	*Nil.*	30	5,993
1910	6,616	59,951	1,510	7,340	1,606	*Nil.*	37	5,002
1911	7,171	78,790	1,494	7,157	1,598	0.1	27	5,115
1912	8,344	62,202	2,175	8,468	2,508	1.8	54	6,356
1913	7,799	67,278	2,066	6,984	1,895	....	39	4,264

Year.	Petroleum Products.			Phosphorus and Phosphoric Acid.	Potassium Salts.			Pyrite.
	Crude Oil.	Refined Oil.	Paraffin.		Carbonate.	Chloride.	Chromate.	
1900	20,813	22,963	5,080	204	1,029	3,633	11	60,317
1901	22,545	18,067	5,294	222	1,442	4,356	21	54,202
1902	24,830	15,864	4,238	225	485	3,377	11	60,235
1903	19,710	19,382	2,598	237	197	3,727	9	73,835
1904	20,110	22,715	1,470	193	222	3,557	3	65,397
1905	18,974	24,961	888	222	154	3,864	5	86,338
1906(*f*)	13,522	9,693	403	178	602	3,729	(*e*) 5	87,973
1907	18,345	11,441	524	219	174	4,807	(*e*)38	130,270
1908	3,118	9,705	358	234	324	5,009	(*e*)98	130,793
1909	1,357	9,093	508	231	314	4,782	(*e*)86	141,858
1910	18,977	16,868	457	253	185	5,052	69	153,106
1911	19,070	19,737	632	233	201	3,666	55	150,974
1912	17,874	21,153	546	258	339	5,280	55	186,690
1913	19,125	31,590	299	255	157	5,216	175	130,526

Year.	Quicksilver *Kg.*	Salt.	Sand.	Silver.		Slag and Slag Wool.	Roofing Slate.
				Bullion. *Kg.*	Specie.		
1900	1,300	39,822	77,930	29,300	$199,955	....	13,047
1901	2,600	39,625	83,401	41,800	207,669	....	11,555
1902	1,300	46,128	92,617	177,900	237,104	....	14,378
1903	1,600	48,793	94,492	150,400	250,299	....	11,531
1904	2,500	94,103	97,364	36,700	420,413	....	9,170
1905	2,400	......	104,195	36,100	143,152	....	8,852
1906(*f*)	1,800	32,182	134,526	43,000	200,754	109,827	6,020
1907	1,200	41,660	180,280	88,182	170,228	107,783	7,537
1908	2,000	54,525	177,529	96,700	101,265	115,445	7,178
1909	2,600	75,397	183,169	150,980	172,201	155,812	6,915
1910	2,300	96,936	188,762	161,600	121,000	147,192	9,019
1911	2,900	99,921	225,743	195,000	70,102	147,179	8,060
1912	3,700	113,287	249,766	91,110	78,361	204,946	7,824
1913	4,400	110,923	235,775	148,580	206,032	214,726	6,351

Year.	Sodium Salts.						Sulphur.
	Bi-sulphate.	Carbonate.	Carbonate (Calcined).	Hydrate.	Nitrate.	Sulphate.	
1900	73	104	1,141	1,836	54,559	5,110	27,795
1901	98	77	911	1,280	63,283	4,452	25,300
1902	17	97	312	1,030	39,958	5,997	23,878
1903	13	110	327	956	54,896	6,116	22,625
1904	103	103	1,109	659	54,887	5,409	30,505
1905	167	168	965	475	66,740	5,258	30,227
1906(*f*)	86	382	303	218	49,862	7,508	26,755
1907	72	153	283	305	57,023	7,342	34,261
1908	32	124	288	358	69,722	7,596	30,985
1909	26	149	297	832	80,533	9,402	28,639
1910	15	224	354	341	81,781	10,150	34,936
1911	5	297	337	297	65,781	10,842	34,916
1912	10	(*i*)455	260	302	92,838	14,454	40,913
1913	12	247	262	102	93,025	12,682	39,228

Year.	Sulphuric Acid.	Tin. Ingot, Crude, Old, etc.	Whetstones.	Zinc.			
				Calamine and Other Ores.	Spelter.	Bars, Sheets, Wires, etc.	White.
1900	10,643	3,439	3,643	14,181	17,844	667	875
1901	11,712	3,671	3,445	18,403	16,921	579	718
1902	12,474	3,638	3,599	20,723	17,034	651	636
1903	16,148	3,564	3,774	22,344	17,973	746	698
1904	19,878	3,528	4,272	24,039	20,787	731	840
1905	17,320	3,845	4,376	22,890	21,874	568	972
1906(*f*)	17,020	3,320	4,377	24,014	19,467	595	347
1907	20,430	4,433	5,552	24,289	24,092	604	219
1908	25,251	4,295	5,916	19,366	26,472	1,010	361
1909	27,368	4,587	6,826	24,639	27,148	1,263	349
1910	27,421	4,674	6,915	30,880	29,168	1,898	511
1911	26,630	4,795	8,066	31,357	33,740	388	471
1912	36,714	4,806	6,826	35,376	37,558	1,260	438
1913	24,922	4,214	6,579	52,299	31,841	1,264	392

(*a*) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (*b*) Includes arsenious acid and sulphide. (*c*) Includes burned asbestos. (*d*) The values of gold are figured at the rate of one crown = $0.203. (*e*) Potassium and Sodium. (*f*) Last 10 months only. (*g*) Metric tons. (*h*) Not including 188,884 tons of briquettes. (*i*) Includes bicarbonate.

MINERAL EXPORTS OF AUSTRIA-HUNGARY (*a*)
(In metric tons or dollars; 5 crowns = $1)

Year.	Alum.	Aluminium Sulphate and Chloride.	Antimony.		Arsenic, Metallic Oxide, Orpiment, and Realgar.	Asbestos.		Asphalt.	
			Ore.	Regulus.		Crude.	Manu-factured.	Rock and Earth.	Mastic and Bitumen.
1900	44	164	247	276	65	47	168	1,218	2,177
1901	55	211	179	385	80	36	165	198	1,909
1902	102	135	174	290	89	65	275	520	301
1903	77	14	128	249	63	89	495	921	483
1904	38	2	200	673	72	290	1,582	403	728
1905	68	34	178	774	42	330	1,397	1,060	457
1906 (*f*).	68	80	314	912	66	376	1,708	2,824	799
1907	75	81	92	698	59	351	630	3,787	771
1908	147	92	161	527	51	442	450	1,312	1,030
1909	65	57	97	185	117	264	561	1,800	758
1910	346	85	54	416	9	262	604	1,545	954
1911	157	16	77	267	13	141	992	1,845	1,218
1912	253	7	54	689	2	530	779	1,357	1,920
1913	454	5	......	....	....	243	1,605	326	2,621

Year.	Barium.		Chloride of Lime.	Cement.	Chrome Ore.	Kaolin and Feldspar.	Coal.		Coke.
	Sulphate (*b*)	Chloride.					Bitumin-ous.	Lignitic.	
1900 ...	23	....	192	46,761	22	103,178	815,097	7,864,410	262,793
1901 ...	55	4,098	738	44,723	62	97,037	748,802	8,076,575	303,651
1902 ...	64	4,552	426	39,920	51	100,546	691,680	7,888,218	234,911
1903 ...	52	5,091	674	40,239	100	110,181	754,957	8,027,347	280,395
1904 ...	74	4,233	254	43,110	36	127,984	815,570	7,588,555	353,695
1905 ...	26	4,626	978	52,830	46	137,125	903,156	8,035,718	287,790
1906(*f*)	2,395	4,503	271	64,883	102	133,326	750,420	7,150,339	246,914
1907 ...	3,119	5,220	308	81,407	161	157,894	849,792	8,876,408	323,243
1908 ...	2,987	2,974	519	65,597	144	154,146	762,867	8,600,683	183,279
1909 ...	2,585	3,737	462	63,463	174	150,878	633,253	8,241,723	198,313
1910 ...	13	4,344	1,213	98,888	140	164,859	615,082	7,492,447	230,735
1911 ...	12	3,741	1,175	168,321	70	174,493	609,737	7,063,981	299,915
1912 ...	2,690	3,658	1,518	149,860	95	187,358	655,106	7,442,392	349,384
1913 ...	753	4,918	2,042	144,596	142	197,693	708,975	7,016,606	369,802

Year.	Fluorspar.	Copper.			Copper Sulphate.	Copperas.	Cryolite.
		Ore.	Crude and Old.	Bars, Sheets, Plates, etc.			
1900..........	45.0	801	471	200	57	748	237
1901..........	6.0	1,042	435	334	23	548	231
1902..........	42.0	1,018	436	381	44	857	363
1903..........	12.0	1,308	1,226	451	45	898	521
1904..........	36.0	574	747	577	50	1,170	574
1905..........	5.0	2,328	1,253	746	49	836	638
1906..........	*Nil.*	341	1,007	816	99	861	*Nil.*
1907(*f*)........	*Nil.*	489	624	870	11	1,580	*Nil.*
1908..........	7.0	206	1,126	791	63	2,199	*Nil.*
1909..........	12.0	136	1,250	541	40	1,877	*Nil.*
1910..........	4.0	101	977	700	83	2,273	42
1911..........	0.2	126	1,309	1,109	14	2,124	122
1912..........	13.0	516	1,332	1,642	119	3,090	46
1913..........	15.0	182	1,379	1,297	172	2,653	....

Year.	Gold.			Graphite.	Gypsum.		Hydrochloric Acid.
	Ore.	Bullion. (*e*)	Specie. (*e*)		Crude.	Calcined.	
1900	1	$120,988	$11,582,571	18,995	502	1,723	1,659
1901	0	42,427	6,880,888	14,900	461	1,206	1,632
1902	....	22,939	13,485,087	16,771	550	1,041	791
1903	3	10,150	11,052,944	17,302	342	1,510	3,530
1904	64	5,278	9,649,605	17,430	392	1,510	3,722
1905	1,059	9,338	10,995,089	18,535	363	1,652	4,085
1906	936	88,264	8,015,967	16,871	1,970	686	2,942
1907 (*f*)	996	1,234,291	13,061,517	21,704	3,841	801	3,708
1908	613	70,005	11,978,828	16,535	7,241	807	3,720
1909	548	3,426,539	19,470,382	18,484	3,675	809	3,263
1910	(*h*)	1,750,600	10,891,800	21,191	5,110	590	4,856
1911	(*h*)	6,909,408	15,220,358	21,204	3,689	914	5,834
1912	573	10,952,642	21,008,500	25,246	4,113	1,174	8,461
1913	102	2,092,318	13,719,496	24,492	2,544	988	8,969

Year.	Iron.				Lime.	Magnesium Chloride and Glauber Salts.	Magnesite (Calcined).
	Ore.	Pig and Old.	Manufactures.	Iron and Steel Bars, Sheets, Wire, etc.			
1900	263,421	53,426	40,344	65,019	86,273	7,321	(*c*)
1901	229,624	26,304	46,508	28,841	82,399	7,960	40,236
1902	241,806	42,592	30,137	45,517	81,634	5,333	53,467
1903	252,520	60,237	40,807	63,031	95,644	2,360	69,058
1904	295,017	66,442	60,252	64,698	101,753	2,151	53,781
1905	373,077	63,780	63,828	69,672	94,751	1,272	92,359
1906(*f*)	234,924	43,694	73,575	50,247	87,468	4,094	87,765
1907	220,767	37,581	56,472	69,669	89,305	6,905	113,695
1908	220,357	17,494	32,110	29,227	62,938	2,622	87,049
1909	178,464	22,627	25,455	40,837	77,586	5,446	125,666
1910	144,827	96,114	73,473	100,541	391,989	6,332	182,911
1911	114,166	87,975	60,918	75,630	511,996	2,715	147,481
1912	111,436	50,328	48,147	49,907	583,812	2,212	171,196
1913	106,071	21,148	....	....	678,194	2,151	200,947

Year.	Lead.						Manganese Ore.	Millstones.	Mineral Paints.	Nickel and Cobalt Ores.
	Ore.	Dross.	Litharge.	Metal and Alloys.	Red and Yellow.	White.				
1900	2,628	66	242	393	34	34	463	1,871	1,906	114
1901	4,143	112	179	68	32	23	398	1,971	1,947	120
1902	5,478	154	124	109	25	37	411	1,886	2,136	34
1903	8,961	147	145	152	19	25	724	2,311	1,873	12
1904	7,575	144	167	464	54	52	1,234	2,276	1,840	26
1905	7,944	342	141	957	60	39	995	2,232	2,091	16
1906(*f*)	4,891	223	302	602	16	52	4,170	1,763	1,367	42
1907	8,360	420	255	197	9	54	5,273	2,422	1,697	29
1908	7,107	488	312	199	22	50	2,109	3,293	2,292	*Nil.*
1909	5,711	294	343	306	125	80	787	3,849	2,577	*Nil.*
1910	6,163	322	160	418	44	510	285	3,970	3,542	13
1911	5,493	154	768	670	24	35	588	3,513	3,426	1
1912	8,618	......	28	548	19	82	534	3,530	4,272	0.3
1913	2,828	......	36	1,060	3	32	550	3,083	3,831	4.0

Year.	Nitric Acid.	Ozokerite.	Peat and Peat Coke.	Petroleum. (*d*)	Benzine.	Paraffin.	Potash.	Potassium Chloride.	Pyrite.	Sulphur.
1900....	519	5,162	5,607	33,032	18,361	26	7,792	879	17,162	1,285
1901....	632	2,717	4,558	19,804	17,021	14	4,234	909	16,491	1,225
1902....	769	2,285	4,927	40,683	13,884	24	3,229	772	9,547	1,136
1903....	908	2,258	3,638	74,454	14,000	1,153	3,409	802	10,857	1,123
1904....	858	2,093	3,980	122,419	13,706	5,992	4,604	445	9,891	988
1905....	1,377	1,614	3,746	200,736	8,187	8,996	5,511	1,048	9,168	859
1906(*f*)	1,303	2,034	2,517	198,325	13,472	9,996	3,814	1,005	7,208	760
1907....	754	1,813	4,001	212,527	12,638	14,758	5,864	1,280	5,646	784
1908....	882	1,648	4,416	351,262	25,599	28,808	4,697	776	6,286	998
1909....	745	2,321	3,395	470,085	32,532	38,043	5,667	793	4,975	1,295
1910....	1,121	2,585	1,963	271,467	39,452	44,432	5,271	957	4,565	658
1911....	1,047	1,859	2,869	220,499	41,923	38,058	4,801	943	1,190	534
1912....	1,251	2,525	1,421	338,271	68,698	51,694	4,456	855	5,041	1,048
1913....	1,373	2,275	1,155	245,184	49,773	43,102	7,460	1,370	3,885	312

Year.	Sulphuric Acid.	Tin.			Whetstones.	Zinc.				
		Ingot and Alloys.	Bars, Plates, Sheets, etc.	Dross.		Ore.	Metallic and Alloys.	Sheets, etc.	White.	Dross.
1900...	12,693	153	102	208	2,270	20,379	1,088	502	1,719	149
1901...	10,373	162	109	257	2,359	23,150	1,374	813	2,720	167
1902...	9,451	193	128	188	2,852	24,519	2,002	1,127	3,113	237
1903...	8,369	292	111	158	2,569	15,108	4,420	729	3,446	267
1904...	9,101	126	102	123	2,159	17,314	4,606	532	3,666	158
1905...	12,823	197	94	78	2,355	19,602	5,023	498	3,861	113
1906(*f*)	10,493	221	62	83	1,541	15,933	4,578	323	3,504	4,285
1907...	15,190	333	84	160	1,900	19,516	4,608	585	4,873	4,873
1908...	13,581	257	49	172	2,009	19,233	6,604	880	4,131	4,131
1909...	11,232	558	82	59	1,677	19,970	7,031	867	5,078	5,078
1910...	12,016	509	58	70	2,411	22,397	8,720	303	4,968	(*g*)
1911...	12,111	759	77	59	1,769	16,744	710	411	4,639	(*g*)
1912...	16,216	(*i*)1,038	42	......	1,414	14,539	(*i*)10,356	2,483	5,890	......
1913...	14,902	1,061	32	......	1,358	16,376	13,174	1,383	5,514	......

(*a*) From *Statistik des Auswaertigen Handels des Oesterreichisch-Ungarischen Zollgebiets.* (*b*) Includes artificial barium sulphate. (*c*) Previous to 1901, magnesite was included with other minerals not elsewhere specified. (*d*) From 1895 to 1898, inclusive, includes crude and refined petroleum; from 1899 to 1905, inclusive, lubricating oil is also included. (*e*) Where gold or silver values are reported, 1 crown = $0.203. (*f*) Last 10 months only. (*g*) Not reported. (*h*) Values in gold, $40,200 and $38,760. (*i*) Includes dross.

BELGIUM

Figures in full-faced type are either provisional figures or estimates.

MINERAL, METALLURGICAL AND QUARRY PRODUCTION OF BELGIUM (a)

(In metric tons except where otherwise noted)

Year.	Barytes.	Chalk-marl. *Cubic Meters.*	Coal.		Coke.	Flint. *Cubic Meters.*	Iron Ore.
			Bituminous.	Briquets.		For Earthenware.	
1900....	38,800	3,228,205	23,462,817	1,395,910	2,434,678	25,700	247,890
1901....	22,800	1,497,250	22,213,410	1,587,800	1,847,730	17,700	218,780
1902....	33,000	1,626,670	22,877,470	1,616,520	2,102,650	17,430	166,480
1903....	21,000	1,580,330	23,796,680	1,686,415	2,428,020	16,250	184,400
1904....	60,000	1,645,655	(*e*)22,761,430	1,735,480	2,496,340	18,070	206,730
1905....	26,000	1,493,745	21,775,280	1,711,920	2,526,690	12,800	176,620
1906....	22,365	1,521,660	23,569,860	1,887,090	2,712,760	14,900	232,570
1907....	23,000	1,537,210	23,705,190	2,040,670	2,771,920	15,050	316,250
1908....	25,070	1,441,005	23,557,900	2,421,210	2,632,890	15,430	188,780
1909....	31,400	1,445,015	23,517,550	2,707,390	2,972,920	15,280	199,710
1910 ...	4,900	1,546,750	23,916,560	2,651,190	3,110,820	16,400	122,960
1911....	25,200	1,667,125	23,053,540	2,778,620	3,160,950	10,950	150,500
1912....	32,400	1,745,070	22,972,140	2,690,510	3,175,500	5,930	167,370
1913....	12,000	1,687,085	**22,845,310**	**2,608,640**	**3,447,310**	16,690	150,450

Year.	Iron, Crude.					Iron and Steel.			
	Foundry Pig.	Forge Pig.	Bessemer Pig.	Basic Pig.	Total Pig.	Ingots of Steel.	Merchant Bars.	Beams & Special Bars.	Tires.
1900....	88,335	305,344	176,557	447,271	1,018,561	655,199	....	....	11,934
1901....	86,170	178,250	166,820	332,940	764,180	515,780	334,910	186,200	12,380
1902....	104,540	254,710	199,170	510,630	1,069,050	769,040	380,990	223,380	12,790
1903....	91,600	256,890	229,160	638,430	1,216,080	969,230	446,360	138,270	17,810
1904....	99,350	224,410	217,390	742,040	1,287,597	1,065,870	543,260	268,360	23,540
1905....	98,170	206,390	220,210	784,850	1,311,120	1,200,430	570,130	299,840	25,810
1906....	96,090	218,225	177,900	870,860	1,375,775	1,440,860	552,850	346,420.	32,070
1907....	92,280	189,190	88,650	1,008,170	1,406,980	1,521,610	594,170	327,930	34,700
1908....	76,290	116,740	78,950	996,870	1,270,050	1,249,620	544,810	241,060	29,000
1909....	91,040	127,080	56,430	1,340,060	1,616,370	1,580,350	628,740	291,260	33,960
1910....	82,410	115,760	55,650	1,596,970	1,852,090	1,892,160	672,730	340,850	31,860
1911....	52,970	102,690	46,240	1,836,720	2,046,280	2,128,170	711,220	380,160	35,450
1912....	94,810	66,940	44,250	2,093,480	2,301,290	2,442,420	609,930	390,340	40,320
1913....	93,830	66,370	32,260	2,291,390	2,484,690	3,104,780	855,547	213,940	175,210

Year.	Iron and Steel.				Lead.		Manganese Ore.
	Rails.	Plates.	Sheets.	Total Wrought and Steel.	Ore.	Pig.(*a*)	
1900	134,428	....	....	926,752	230	16,365	10,820
1901	132,260	95,190	55,300	870,230	220	61,900	8,510
1902	(*c*)268,220	101,280	67,350	1,106,950	164	73,357	14,440
1903	(*c*)351,540	113,830	74,080	1,376,630	90	68,700	6,100
1904	(*c*)266,900	126,960	79,040	1,378,750	91	(*f*)23,470	485
1905	241,640	167,240	76,510	1,469,020	126	22,885	*Nil.*
1906	274,920	166,970	84,150	1,522,995	121	23,765	120
1907	314,760	148,690	82,420	1,575,110	210	27,450	2,100
1908	(*c*)191,370	135,390	93,790	1,296,050	195	35,650	7,130
1909	214,000	170,750	112,160	1,569,560	150	40,306	6,270
1910	347,890	177,110	122,830	1,834,050	162	40,715	*Nil.*
1911	337,520	211,410	130,250	1,945,220	82	44,308	*Nil.*
1912	339,060	251,380	119,390	1,903,270	107	54,940	*Nil.*
1913	341,870	241,200	137,570	2,224,057	**132**	**35,750**	*Nil.*

Year.	Mineral Paints.	Phosphate of Lime.	Pyrite.	Slate. *Pieces.*	Silver. *Kg.*	Zinc.			
	Ochers.					Ore (Blende)	Ore (Calamine).	Spelter.	Sheets
1899	(*b*) 300	(*b*)190,090	283	44,167,000	134,854	5,736	3,730	122,843	34,289
1900	(*b*) 300	(*b*)215,670	400	43,941,000	146,548	5,715	3,000	119,317	38,825
1901	2,100	222,520	560	39,030,000	169,450	4,445	2,200	127,170	37,380
1902	200	135,850	760	37,120,000	212,922	3,568	284	124,780	37,070
1903	200	184,120	720	38,953,000	232,740	3,565	65	131,740	42,280
1904	450	202,480	1,075	41,240,000	252,920	3,698	4	137,323	41,490
1905	300	193,305	976	41,435,000	201,935	3,929	*Nil.*	142,555	45,320
1906	250	152,140	908	43,801,000	173,535	3,858	*Nil.*	148,035	44,525
1907	200	181,230	397	40,102,000	178,020	3,485	5	152,370	45,330
1908	....	198,030	357	41,180,000	228,000	2,099	3	161,940	43,410
1909	700	205,260	214	41,630,000	271,270	1,229	*Nil.*	174,490	44,850
1910	600	202,880	214	36,440,000	264,655	1,434	*Nil.*	181,745	47,970
1911	540	196,780	122	37,620,000	252,720	836	*Nil.*	198,230	48,450
1912	650	203,110	148	29,600,000	279,960	1,167	*Nil.*	205,940	49,120
1913	600	219,420	**268**	27,390,000	253,940	**1,100**	*Nil.*	204,225	51,490

(*a*) From *Statistique des Industries Extractives et Metallurgiques et des Appareils à vapeur en Belgique.* (*b*) Cubic meters. (*c*) Includes beams. (*e*) Net production from this year on. (*f*) Domestic lead only, beginning with this year.

CANADA

The statistics of mineral production in the Dominion of Canada as reported by the Geological Survey are summarized in the following tables. The statement of imports and exports for 1907 is for the nine months ending March 31, in consequence of a change in the law whereby the fiscal year was changed from June 30:

MINERAL PRODUCTION OF THE DOMINION OF CANADA (*a*)
(In metric tons or dollars)

Year.	Arsenic.	Asbestos and Asbestic.	Barytes.	Cement. *Barrels.* (*j*) Natural Rock.	Cement. *Barrels.* (*j*) Portland.	Chromite.	Coal.	Cobalt and Oxid	Coke. (*k*)
1902....	726	36,657	994	127,931	594,594	900	6,524,180	.....	455,353
1903....	725	37,902	1,055	92,252	627,741	3,509	6,933,107	.....	509,115
1904....	(*d*) 66	44,131	1,253	51,555	771,650	5,511	6,812,834	.....	493,107
1905....	*Nil.*	61,928	3,049	14,184	1,346,547	7,781	7,961,397	.....	622,154
1906....	*Nil.*	72,025	3,628	8,610	2,139,164	7,936	9,033,973	.....	(*b*)
1907....	317	82,117	1,829	5,775	2,368,593	6,527	9,533,442	.....	(*b*)
1908....	634	82,448	3,911	1,044	2,665,289	7,341	9,857,754	841	784,788
1909....	1,024	79,197	(*b*)	(*b*)	4,067,709	2,240	9,526,938	(*i*)	782,016
1910....	1,362	92,800	(*b*)	(*b*)	4,753,975	276	11,711,000	(*i*)	818,450
1911....	1,902	115,136	45	(*b*)	5,692,915	143	10,243,528	(*i*)	848,280
1912....	1,855	123,679	421	(*b*)	7,132,732	(*b*)	13,168,941	(*i*)	1,275,829
1913....	1,535	146,169	581	(*b*)	8,658,805	(*b*)	13,622,070	(*i*)	1,376,646
1914....	1,576	106,686	555	(*b*)	7,172,480	123	12,336,088	(*i*)	921,241
1915....	2,079	125,966	499	(*b*)	5,681,032	10,423	11,533,005	268	1,089,624

Year.	Copper. (In Ore, etc.)	Corundum.	Feldspar.	Gold. (*c*)	Graphite.	Grindstones.	Gypsum.	Iron Ore.	Iron, Pig. All kinds.
1902..	17,598	697	6,871	$21,336,667	993	5,835	301,165	366,431	324,617
1903..	19,357	880	12,633	18,843,590	660	5,023	285,242	239,715	270,182
1904..	19,497	834	10,057	16,400,000	410	4,091	309,133	317,387	275,367
1905..	21,596	1,492	10,617	14,486,833	491	4,693	395,341	263,113	475,491
1906..	25,863	2,063	14,397	12,023,932	405	5,029	378,904	269,842	550,628
1907..	26,025	1,716	11,414	8,264,765	525	4,881	431,286	283,820	590,444
1908..	28,895	988	7,144	9,842,105	227	3,285	309,254	215,986	572,284
1909..	23,811	1,353	11,594	9,382,230	783	3,877	429,218	(*d*) 243,167	(*g*) 686,886
1910..	25,262	1,696	14,114	10,205,835	1,263	3,604	476,496	(*d*) 235,342	(*g*) 726,471
1911..	25,250	1,336	16,074	9,781,077	1,151	4,818	458,550	190,823	(*g*) 832,376
1912..	35,314	1,778	12,461	12,648,794	1,869	4,003	524,892	107,190	(*g*) 920,636
1913..	34,926	1,068	15,235	16,598,923	1,962	4,389	577,442	196,558	(*g*) 1,024,424
1914..	34,364	507	16,388	15,925,044	1,494	3,700	463,375	54,816	(*g*) 710,675
1915..	46,548	238	14,025	18,936,971	2,368	2,341	422,264	84,795	(*g*) 829,146

Year.	Iron and Steel, Rolled.	Lead. (In ore, etc.)	Manganese Ore.	Mica.	Mineral Paints. (Ochers)	Natural Gas.	Nickel. (In ore, etc.)	Petroleum, Crude. *Barrels.* (*e*)
1902....	164,069	10,411	(*d*) 156	$135,904	4,494	$195,992	4,849	530,624
1903....	131,588	8,226	83	177,857	5,683	202,210	5,671	486,637
1904....	(*b*)	17,241	(*d*) 112	152,919	3,562	247,370	4,786	552,575
1905....	(*b*)	25,391	(*d*) 20	168,170	4,632	314,249	8,565	634,095
1906....	(*b*)	24,580	(*d*) 84	(*d*) 581,043	6,201	528,868	9,745	569,753
1907....	(*b*)	21,570	....	333,022	7,115	748,541	9,610	788,872
1908....	(*h*) 534,117	19,593	....	139,871	4,305	1,012,660	8,685	527,987
1909....	(*h*) 684,670	20,801	....	147,782	3,573	1,207,029	11,922	420,755
1910....	(*h*) 745,963	14,963	....	190,385	4,365	1,346,471	16,905	315,895
1911 ...	(*h*) 800,722	10,617	5	128,667	3,285	1,917,673	15,457	291,092
1912....	868,617	16,227	68	143,976	6,945	2,362,700	20,346	243,336
1913....	....	17,089	0	194,304	5,432	3,309,381	22,539	228,080
1914....	....	16,487	25	109,061	5,345	3,484,727	20,652	214,805
1915....	....	20,589	43	81,021	5,670	3,300,825	30,888	215,464

Year.	Phosphate. (Apatite.)	Pyrite.	Salt.	Silver. *Kg.* (In ore, etc.)	Soapstone and Talc.
1902	776	32,304	58,462	133,478	625
1903	1,205	30,822	56,644	99,489	898
1904	832	29,980	62,411	115,666	762
1905	1,180	29,713	41,159	185,839	454
1906	(*b*)	35,927	69,283	266,521	1,119
1907	680	35,494	65,936	390,359	1,391
1908	1,447	42,934	72,537	687,504	976
1909	905	58,645	76,237	856,263	3,945
1910	1,341	48,871	76,286	1,022,350	6,450
1911	563	74,978	83,065	1,012,586	6,621
1912	149	73,976	86,248	993,952	7,504
1913	349	143,882	91,457	990,538	11,115
1914	866	204,125	97,126	856,741	9,807
1915	197	269,428	108,802	805,184	10,785

(*a*) From *Reports Compiled by the Geological Survey of Canada.* (*b*) Not reported. (*c*) Gold values are calculated at the rate of $20.67 per oz. (*d*) Export. (*e*) One barrel contains 35 imp. gal. (*g*) From Canadian ore, 149,444 short tons in 1909, 104,906 tons in 1910, 42,186 tons in 1911, 36,355 tons in 1912, 73,508 tons in 1913, 95,744 in 1914 and 158,598 short tons in 1915. (*h*) Steel ingots and castings. (*i*) 1909, $94,609; 1910, $51,986; 1911, $221,790; $320,244 in 1912, $695,855 in 1913 $678,619 in 1914, for oxides of cobalt and nickel; values received. (*j*) Bbl. of 350 lb. each, sold or shipped. (*k*) Including that from foreign coal.

MINERAL IMPORTS OF THE DOMINION OF CANADA (*a*)
(In metric tons or dollars)

Year. (*b*)	Aluminium.		Antimony. (*c*)	Arsenic.	Asbestos. (*d*)	Asphalt.	Cement.
	Manufactures. (*m*)	Ingots, Sheets, etc.					
1903	$14,201	$13,930	393	135	$75,465	3,037	$890,745
1904	16,065	101,427	190	188	83,827	7,093	1,014,713
1905	28,418	154,569	85	122	116,836	5,096	1,263,828
1906	23,565	168,405	183	202	138,000	7,178	1,003,022
1907(*o*)	20,656	218,399	146	158	127,509	11,929	540,006
1908(*r*)	37,197	131,762	220	228	191,204	14,113	865,275
1909(*r*)	30,076	167,019	201	58	181,710	15,979	473,211
1910(*r*)	42,493	424,006	232	12	198,756	19,661	159,040
1911(*r*)	83,638	782,254	257	115	254,331	23,248	(*t*)494,446
1912(*r*)	119,070	487,490	233	159	349,655	28,291	(*t*)936,425
1913(*r*)	126,531	403,700	400	259	497,160	47,353	(*t*)1,955,177
1914(*r*)	151,261	730,012	322	127	474,499	48,564	(*t*)352,134
1915(*r*)	87,242	672,527	733	8	226,515	38,175	(*t*)132,492
1916(*r*)	11,842	700,365	595	146	191,886	38,029	45,295

Year.	Coal.		Coke.	Copper. Ingots, Pig, and Scrap.	Copper Sulphate.	Gold and Silver. Coin and Bullion. (*g*)
	Anthracite. (*f*)	Bituminous. (*f*)				
1903	1,320,239	3,684,502	232,848	924	1,010	$8,976,797
1904	2,064,444	4,230,436	200,590	960	795	7,874,313
1905	2,361,952	4,377,667	337,035	882	934	10,308,435
1906	1,996,183	5,003,029	435,561	1,191	844	7,078,603
1907(*o*)	1,260,723	4,022,843	363,286	1,186	897	7,029,047
1908(*r*)	2,803,681	7,681,464	561,677	1,638	1,161	6,548,661
1909(*r*)	2,775,680	6,526,797	423,013	1,239	963	9,988,442
1910(*r*)	2,860,196	10,382,156	636,888	2,329	859	6,017,589
1911(*r*)	3,144,130	7,785,259	692,292	2,279	772	10,206,210
1912(*r*)	3,736,169	9,526,138	582,331	2,514	930	26,033,881
1913(*r*)	3,844,062	10,034,383	644,207	2,581	1,153	5,527,979
1914(*r*)	3,979,674	12,479,959	643,693	2,511	606	15,235,317
1915(*r*)	3,971,968	8,279,570	460,381	2,053	335	131,993,031
1916(*r*)	4,429,143	9,631,101	693,607	1,689	862	34,260,202

Year.	Graphite.		Gypsum.		Iron and Steel.		
	Crude.	Manufactures. (*h*)	Crude and Ground.	Plaster of Paris.	Pig and Scrap.	Slabs, Blooms Bars, etc.	Alloys of Iron.
1904.........	$1,802	$67,563	626	291	86,087	9,088	2,700
1905.........	2,499	75,288	2,972	3,595	90,698	14,420	11,738
1906.........	2,791	86,028	5,743	6,579	112,937	29,520	13,626
1907(*o*)......	3,176	57,430	8,334	9,730	137,654	17,369	17,785
1908(*r*).......	3,030	78,380	8,519	6,955	190,994	35,534	16,139
1909(*r*)......	1,408	75,608	9,359	7,712	62,967	43,263	13,571
1910(*r*)......	5,223	95,900	3,618	19,095	159,515	97,036	14,471
1911 (*r*)......	4,300	97,057	11,443	19,664	266,269	139,060	15,773
1912(*r*).......	6,163	84,240	2,130	9,313	214,046	80,250	16,578
1913(*r*).......	6,105	89,719	8,800	28,975	306,927	77,176	20,837
1914(*r*)......	3,639	71,340	4,877	15,084	251,730	145,731	26,256
1915(*r*)......	1,464	43,313	3 236	5,769	69,261	50,086	2,534
1916(*r*)......	3,620	48,614	1,658	2,222	54,936	122,786	12,761

Year.	Kainite.	Lead.				Lime.		Mineral Paints (Ochers).
		Pig and Scrap.	Bars and Sheets.	Litharge.	Pigments and Zinc White.	Burned. *Barrels.*	Chloride.	
1904...	339	4,292	....	....	7,679	54,359	2,080	1,256
1905...	306	2,589	800	811	9,695	98,676	2,507	1,417
1906...	306	3,751	730	461	6,947	134,334	2,645	809
1907 (*o*)	511	3,811	622	513	2,215	88,919	2,302	570
1908 (*r*)	743	2,902	782	864	5,743	129,379	3,421	788
1909 (*r*)	562	2,273	623	550	3,998	153,934	2,697	546
1910 (*r*)	687	5,755	580	915	4,433	191,527	4,554	914
1911 (*r*)	339	5,292	707	750	5,312	176,730	4,745	1,169
1912 (*r*)	262	10,934	1,356	745	4,921	230,013	5,584	1,358
1913 (*r*)	19	10,980	918	1,197	6,627	360,242	5,248	1,649
1914 (*r*)	180	5,078	654	512	7,547	....	6,264	1,605
1915 (*r*)	350	7.539	358	479	5,350	....	2,446	1,282
1916 (*r*)	44	22,928	477	1,043	6,090	....	4,973	1,162

Year.	Nickel.	Petroleum Products.		Platinum.	Potassium Salts.		Quicksilver.
		Illuminating Oil, etc., Crude or Refined. *Gallons.*	Paraffin Wax and Candles.		Except Saltpeter.	Saltpeter.	
1904........	$14,682	24,521,115	228	$28,112	1,151	898	69
1905........	19,076	13,229,855	98	61,719	945	1,048	47
1906........	15,976	10,981,611	375	54,494	1,317	1,141	68
1907(*o*).....	19,461	8,066,403	189	113,967	1,074	638	44
1908(*r*).....	....	8,844,129	102	63,582	3,396	2,653	81
1909(*r*).....	(*s*)67,107	13,095,593	103	47,371	1,570	925	42
1910(*r*).....	(*s*)98,238	(*u*)48,384,763	253	80,180	2,497	665	129
1911 (*r*).....	137,114	(*u*)66,119,105	931	136,823	3,152	1,490	59
1912(*r*).....	135,227	88,916,283	808	190,770	3,734	1,049	49
1913(*r*).....	194,079	164,013,894	892	221,300	5,643	835	67
1914(*r*).....	144,343	202,540,731	717	121,336	8,057	776	115
1915(*r*).....	172,037	211,900,141	623	65,008	4,139	1,034	67
1916(*r*).....	239,495	213,670,889	549	100,415	1,706	850	83

Year.	Sal-Ammoniac.	Salt.	Silex.	Sodium Salts, Except Chloride.	Sulphur.	Tin and Tin-ware.	Zinc.
1904...	93	103,635	252	25,118	8,786	$2,389,557	1,540
1905...	143	97,723	405	26,219	10,633	2,791,757	1,721
1906...	209	99,788	338	30,401	19,512	3,105,876	3,383
1907(o).	130	73,156	542	25,068	11,725	2,473,572	2,761
1908(r).	172	105,286	1,131	39,154	23,494	1,619,647	2,521
1909(r).	162	119,660	417	33,787	19,981	2,984,065	2,993
1910(r).	303	121,473	582	47,913	19,484	3,512,615	(v)7,606
1911(r).	346	111,174	468	62,969	22,935	4,235,848	(v)6,069
1912(r).	377	119,114	337	74,016	20,430	3,710,102	7,217
1913(r).	544	100,494	658	98,561	32,984	3,055,943	9,397
1914(r).	356	132,777	755	100,701	27,093	6,350,610	7,402
1915(r).	430	121,683	582	78,894	39,412	4,783,108	7,230
1916(r).	420	125,804	402	96,321	34,411	5,312,847	7,357

EXPORTS OF DOMESTIC MINERAL PRODUCE FROM THE DOMINION OF CANADA (a)
(In metric tons or dollars)

Year. (b)	Antimony Ore.	Asbestos.	Chromite.	Coal.	Coke.	Copper. (e)
1904........	87	31,444	2,103	1,494,106	61,750	20,279
1905........	340	37,320	3,702	1,465,809	116,387	17,431
1906........	388	40,367	1,640	1,651,203	50,004	20,082
1907(o)......	832	37,194	604	1,165,809	44,669	11,845
1908(r)......	693	53,543	1,585	1,702,673	50,343	25,824
1909(r)......	1	54,188	3,707	1,548,468	70,024	24,642
1910(r)......	33	58,083	1,052	1,822,398	44,343	26,107
1911(r).....	222	63,348	14	2,100,309	54,380	24,950
1912(r).....	1	69,233	....	1,436,798	13,677	25,595
1913(r).....	....	83,299	....	1,920,809	56,271	36,717
1914(r).....	....	96,159	....	1,360,029	66,512	37,772
1915(r).....	306	67,968	72	1,372,431	47,978	28,438
1916(r).....	970	80,611	10,649	1,788,679	39,737	52,995

Year.	Gold. Quartz, Dust, etc.	Graphite.	Grindstones.	Gypsum, Crude.	Iron Ore.	Lead. (p)
1904......	$18,715,539	269	$12,676	247,741	(n)214,309	7,329
1905......	15,208,380	201	27,985	290,574	204,091	23,094
1906......	12,991,916	180	15,793	367,203	134,270	6,158
1907(o)...	7,226,954	3	33,929	249,780	31,011	8,330
1908(r)...	8,817,041	167	28,726	340,235	23,863	12,650
1909(r)...	7,392,610	396	18,019	239,139	3,568	5,459
1910(r)...	6,110,473	1,164	13,754	304,736	28,608	8,395
1911(r)...	5,344,465	362	23,914	325,928	95,080	1,451
1912(r)...	7,211,438	1,395	30,513	324,324	34,162	52
1913(r)...	11,231,476	1,572	27,375	344,183	123,004	93
1914(r)...	13,326,755	1,367	54,584	359,287	103,126	125
1915(r)...	15,406,510	451	45,889	292,800	198,412	328
1916(r)...	16,870,394	366	19,971	348,923	75,212	1,406

Year.	Manganese Ore.	Mica.	Nickel in Ore, Matte, etc.	Petroleum, Crude and Refined.	Pyrites.	Salt. *Bushels.*	Silver (in Ore, Matte, etc). *Kg.*
1904	62	393	6,456	1,208	15,582	42,662	99,472
1905	84	461	5,431	6,441	20,473	5,663	112,076
1906	15	603	10,866	1,741	18,398	23,168	203,323
1907(*o*)...	84	631	7,355	(*q*)3,167	20,148	5,113	274,178
1908(*r*)...	1	409	8,596	(*q*)3,389	17,835	35,543	515,161
1909(*r*)...	3	243	8,895	(*q*)195	23,087	(*w*)3,040	733,248
1910(*r*)...	5	397	13,891	(*q*)9,093	24,439	(*w*)6,088	932,098
1911(*r*)...	2	370	15,771	(*q*)1,493	32,396	(*w*)6,625	1,049,153
1912(*r*)...	12	348	15,073	38,663	25,279	109,963	960,586
1913(*r*)...	7	415	21,849	152,746	3,109	60,536	1,096,835
1914(*r*)...	....	321	22,949	(*q*)25,443	42,006	(*w*)6,165	1,143,337
1915(*r*)...	82	387	20,604	(*q*)18,376	87,021	(*w*)15,865	788,656
1916(*r*)...	489	392	31,912	512,443	131,598	380	864,527

(*a*) From Tables of the *Trade and Navigation of the Dominion of Canada.* (*b*) Fiscal year ending June 30. (*c*) Includes regulus and salts of antimony. (*d*) Asbestos in any form except crude, and all manufactures of. (*e*) Includes copper in ore, matte, regulus, etc. (*f*) Includes coal dust. (*g*) Coin, gold and silver, except U. S. silver coin. (*h*) Includes black lead and crucibles (clay or graphite). (*i*) Includes Canadian lead ore refined in the United States. (*m*) Unclassified. (*n*) Includes chromic iron ore. (*o*) Returns for the 9 months of the fiscal year ending March 31. (*p*) Includes lead contained in ore, etc. (*q*) Gallons. (*r*) Fiscal year ending March 31. (*s*) Includes silver-nickel and German silver. (*t*) Weight, 64,176 tons; 46,821, 247,940, 35,431, and 14,370 net tons. (*u*) Includes all oils. (*v*) Not including manufactures. (*w*) Using 60 lb. per bushel.

CHINA

The official statistics of mineral imports and exports are summarized in the following table:

MINERAL IMPORTS OF CHINA (*a*)
(In metric tons)

Year.	Brass and Yellow Alloys.	Copper.	Lead.	Nickel.	Petroleum. *Gal.*	Quick-silver.	Tin.	Tin-plate.	Zinc.	
									Spelter.	Sheet, etc.
1910...	1,674	2,428	9,247	134	161,399,583	51	2,684	11,569	....	858
1911...	1,244	4,408	8,138	39	235,898,240	49	1,994	21,676	81	769
1912...	970	7,368	6,187	56	197,902,362	49	2,548	21,036	443	861
1913...	1,628	12,144	6,511	109	183,984,052	40	3,566	21,983	529	1,971
1914...	1,646	17,461	7,093	61	225.464,201	21	3,922	25,369	509	851

MINERAL EXPORTS OF CHINA (*a*)
(In metric tons)

Year.	Antimony.		Iron.		Lead.		Quick-silver.	Tin.	Zinc.	
	Ore.	Metal. (*b*)	Ore.	Pig and Mnfd.	Ore.	Pig.			Ore.	Spelter.
1910.....	5,762	6,643	132,561	65,381	5,176	3	48.5	6,510	9,786	328
1911.....	6,812	6,986	112,295	70,906	5,410	11	18.5	6,056	4,599	710
1912.....	2,054	13,531	355,538	12,604	4,276	20	4.3	8,786	7,170	760
1913.....	4,351	13,032	274,064	64,811	4,066	42	2.1	8,390	9,550	908
1914.....	4,972	19,645	299,515	60,068	3,722	235	59.7	7,215	7,374	310

(*a*) From annual reports of the Imperial Chinese Maritime Customs. (*b*) Regulus and refined.

FRANCE

In the following tables are given the statistics of mineral and metal production in France and the French colonies—Algeria, New Caledonia and Tunis—together with the foreign commerce of France in mineral and metal products. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF FRANCE (*a*)
(In metric tons)

Year.	Aluminium.	Antimony.		Arsenic Ore.	Asphaltum.	Barytes.	Bauxite.	Bitumen. (*c*)	Cement.
		Ore.	Metal.						
1901.......	1,200	9,867	1,786	7,491	20,391	4,145	76,620	249,655	1,127,206
1902.......	1,355	9,715	1,725	5,372	......	4,323	96,900	258,295	962,930
1903.......	1,570	12,380	2,748	6,658	......	5,731	133,890	243,295	898,393
1904.......	1,650	9,065	2,116	3,117	22,000	6,944	75,640	227,177	903,632
1905.......	1,905	12,543	2,396	3,627	20,000	5,504	103,207	188,403	922,531
1906.......	3,396	18,567	3,433	6,534	38,231	11,680	117,781	196,375	1,257,861
1907.......	4,700	24,000	3,950	7,900	33,000	11,150	158,000	177,000	1,253,546
1908.......	4,681	26,026	3,850	2,381	41,000	16,277	170,679	171,158	1,359,658
1909.......	6,092	28,105	5,444	2,141	44,800	14,111	130,149	169,000	1,374,574
1910.......	6,425	28,130	4,640	8,045	38,500	11,632	196,056	169,769	1,521,131
1911.......	7,400	29,267	4,775	19,000	39,000	10,064	254,831	170,000	1,795,000
1912.......	10,200	11,018	(*i*)5,406	81,880	31,535	13,620	258,929	312,000	1,924,277
1913.......	13,483	17,036	6,390	70,613	30,892	12,236	309,294	324,601	1,930,066

Year.	Coal.	Lignite.	Peat.	Copper.		Gold.	Gypsum.	
				Ore.	Metal.		Crude.	Calcined.
1902.....	29,365,047	632,423	109,941	828	6,300	(*b*)	219,487	1,572,687
1903.....	34,217,661	688,757	100,348	10,892	6,921	(*b*)	162,766	1,468,830
1904.....	33,502,394	665,572	95,716	2,756	6,900	(*b*)	106,173	1,481,303
1905.....	35,218,000	709,000	98,500	5,068	7,576	$235,447	78,832	1,299,313
1906.....	33,458,000	738,000	92,469	2,547	5,770	511,665	79,568	1,297,861
1907.....	35,989,000	765,000	90,952	2,400	7,800	847,290	87,370	1,316,567
1908.....	36,633,000	751,000	79,759	766	7,935	960,666	92,898	1,326,131
1909.....	37,115,500	724,500	78,600	458	7,823	1,147,400	76,057	1,263,692
1910.....	37,634,893	715,000	48,415	222	12,933	(*h*) 1,706,580	64,181	1,533,298
1911.....	38,521,000	709,000	58,521	35	13,200	(*h*) 1,463,519	59,648	1,640,698
1912.....	41,145,000	751,000	43,000	242	11,907	**1,993,620**	25,900	1,700,000
1913.....	40,050,888	793,330	44,878	521	11,968	153,009	66,218	....

Year.	Iron.				Lead.		Lime.	Manganese Ore.	Millstones.
	Ore.	Pig	Wrought Iron.	Wrought Steel.	Ore. (*d*)	Pig. (*e*)			
1902.	5,003,782	2,405,000	639,600	1,245,800	22,634	19,000	4,796,807	12,536	34,504
1903.	6,219,541	2,840,517	598,910	1,305,709	23,080	23,258	4,727,543	11,583	35,031
1904.	7,022,841	2,999,787	554,632	1,482,708	14,173	18,800	4,583,522	11,254	37,409
1905.	7,395,409	3,077,000	670,000	1,442,000	12,118	24,100	3,694,725	6,751	33,468
1906.	8,481,423	3,314,100	747,900	1,683,500	11,795	25,614	3,869,772	11,189	32,407
1907.	10,008,000	3,590,000	579,900	1,860,000	18,000	24,800	2,438,409	18,200	30,480
1908.	10,057,145	3,400,700	560,200	1,851,900	13,403	26,112	2,535,833	15,865	30,522
1909.	11,890,000	3,573,848	558,000	2,040,364	13,794	26,927	2,211,653	9,378	30,503
1910.	14,605,542	4,038,000	526,000	2,324,000	14,536	20,226	2,110,540	7,925	32,461
1911.	16,639,000	4,470,100	518,000	3,812,665	14,098	23,635	3,291,000	6,036	34,255
1912.	19,160,000	4,939,194	525,000	4,403,688	13,953	31,086	3,807,596	5,576	33,751
1913.	21,918,000	5,207,307	405,972	4,686,866	17,081	28,817	2,838,392	7,732	29,994

Year.	Mineral Paints. (Ochers)	Nickel.	Phosphate Rock.	Pyrite.	Salt.	Silver. *Kg.*	Sulphur Ore. (*g*)	Zinc.	
								Ore.	Metal.
1901....	35,704	1,800	535,676	307,447	910,000	......	7,000	61,539	37,600
1902....	34,770	1,600	543,900	318,235	863,927	......	8,021	57,982	36,300
1903....	34,042	1,500	475,783	322,118	967,531	......	7,375	66,922	37,416
1904....	34,945	1,500	423,521	271,544	1,153,754	......	5,447	52,842	41,600
1905....	37,800	1,800	476,720	267,114	1,162,100	......	4,637	62,150	43,200
1906....	35,550	1,750	469,408	265,261	1,388,500	50,058	2,713	53,466	46,536
1907....	32,856	1,500	432,237	283,000	1,324,000	47,009	2,000	44,000	47,900
1908....	33,060	1,800	485,607	284,717	1,173,000	61,184	2,189	52,611	47,880
1909....	33,540	1,600	397,908	273,221	1,113,000	63,671	2,900	96,903	49,956
1910....	32,870	2,100	333,506	250,432	1,051,427	52,957	2,641	50,624	52,598
1911....	34,542	1,180	312,204	277,900	1,339,000	47,277	1,200	43,761	57,110
1912....	41,810	1,725	313,151	282,202	1,099,000	63,736	1,000	45,929	62,651
1913....	56,240	1,500	298,859	311,167	1,281,978	31,268	659	46,577	67,890

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) Not reported. (*c*) Includes pure bitumen, bituminous schist and sand, and asphaltic limestone. (*d*) Argentiferous lead ore. (*e*) Lead produced from native ores only. (*g*) Sulphur and limestone impregnated with sulphur. (*h*) From ores. (*i*) Regulus and oxide.

MINERAL PRODUCTION OF ALGERIA (*a*)

(In metric tons)

Year.	Anti-mony Ore.	Copper Ore.	Gypsum.		Iron Ore.	Lead-Silver Ore.	Mer-cury.	Onyx.	Phos-phate Rock.	Salt.	Zinc Ore.
			Crude.	Plaster.							
1901...	....	7,267	600	34,740	161,303	1,614	.....	294	265,000	18,518	26,913
1902...	39	1,955	600	35,500	525,012	26	.....	150	305,174	27,263	33,139
1903...	490	100	300	33,000	588,893	499	.....	67	320,834	26,329	43,313
1904...	160	1,804	350	38,420	468,737	511	.....	121	343,317	18,563	47,192
1905...	.....	1,784	.....	34,743	568,609	7,470	.....	270	334,784	26,986	67,922
1906...	50	2,786	.....	27,950	779,826	11,246	.....	216	333,531	22,615	74,351
1907...	799	16,259	.....	26,400	973,445	15,264	590	328	373,763	20,390	71,046
1908...	190	3,330	.....	25,500	943,424	10,626	1,556	300	452,060	25,215	94,398
1909...	163	67	.....	29,000	836,044	11,131	.....	200	345,385	17,817	81,852
1910 (*a*)	(*c*)4475	112	.....	48,500	1,064,909	12,652	50	123	412,319	21,470	94,445
1911...	(*c*)7428	4,939	.....	51,760	1,025,643	17,909	.....	198	335,059	20,431	60,895
1912...	(*c*)2165	316	.....	54,400	1,225,625	24,516	.....	300	373,881	23,950	84,495
1913...	(*c*)582	13,164	700	50,399	1,349,000	13,953	18	168	377,934	26,969	82,256

MINERAL PRODUCTION OF NEW CALEDONIA. (*a*)

(In metric tons.)

Year.	Chrome Iron Ore.	Cobalt. Ore.	Copper Ore.	Nickel. Ore.	Year.	Chrome Iron Ore.	Cobalt Ore.	Copper Ore.	Nickel Ore.
1900.....	10,474	2,438	2	100,319	1907...	57,367	29,800	437	119,000
1901.....	17,451	3,123	6,349	132,814	1908...	25,371	2,360	(*b*) 10	108,000
1902.....	10,281	7,512	3,720	129,653	1909...	40,000	548	9,600	86,000
1903.....	21,437	8,292	10	77,360	1910...	40,000	54	8,000	99,000
1904.....	42,197	8,964	*Nil.*	98,655	1911...	35,000	*Nil.*	1,900	142,000
1905.....	51,374	7,920	*Nil.*	125,289	1912(*c*)	51,516	*Nil.*	(*d*)	74,312
1906	84,211	2,600	207	118,890	1913(*c*)	63,370	......	......	164,406

(*a*) From *Statistique de l'Industrie Minérale.* (*c*) Exports *Echo des Mines.* (*d*) Copper matte worth $101,000.

MINERAL PRODUCTION OF TUNIS (*a*)

(In metric tons)

Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.	Year.	Salt.	Lead Ore.	Phosphate of Lime.	Zinc Ore.
1901....	16,900	8,158	172,000	17,879	1908...	149,600	37,500	1,300,500	26,500
1902....	12,600	12,892	264,930	18,400	1909...	118,400	41,600	1,300,000	24,500
1903....	18,846	12,752	352,088	21,262	1910...	199,700	(*c*)37,000	1,334,000	(*c*)32,500
1904....	23,600	16,800	455,197	27,200	1911...	63,700	36,100	1,592,000	(*c*)27,900
1905....	54,900	15,200	522,000	37,100	1912...	92,000	51,300	2,050,000	37,400
1906...	62,600	14,800	796,000	32,400	1913(*b*)	94,100	52,200	2,170,500	30,300
1907...	78,200	18,600	1,069,000	22,800					

(*a*) From *Statistique de l'Industrie Minérale.* (*b*) From *l'Echo des Mines.*

MINERAL IMPORTS OF FRANCE (*a*) (*k*)

(In metric tons or dollars. 5 f. = $1)

Year.	Alum.	Bitumen. (*f*)	Borax.	Bromides.	Cement.	Coal and Coke.	Copper. Ore.	Copper. Ingot and Mfrs.	Copper. Sulphate.	Copper. Oxide.
1900....	23	39,598	111	10	13,612	14,601,981	9,766	61,638	22,820	84
1901....	39	28,888	128	3	16,232	13,925,623	13,383	47,035	15,313	162
1902....	36	26,053	141	3	15,720	13,137,720	17,862	54,484	22,273	111
1903....	138	27,573	312	9	21,152	14,029,687	9,796	59,126	25,428	129
1904....	370	17,178	3,113	17	21,702	13,936,475	9,942	69,183	30,856	142
1905....	63	24,606	1,736	31	21,954	13,910,523	14,252	70,101	23,805	57
1906....	105	99,336	189	93	24,974	17,848,284	11,932	64,590	15,358	97
1907....	......	31,700	......	......	24,839	18,706,000	12,063	76,282	......	......
1908....	......	48,000	......	......	31,550	18,563,000	15,300	86,985	......	......
1909....	......	54,000	......	......	46,664	19,387,000	27,400	86,143	......	......
1910....	46	36,360	8,322	17	51,905	18,145,872	23,362	93,548	11,887	427
1911....	129	32,207	3,128	12	86,457	19,740,539	24,585	104,724	17,759	151
1912....	190	39,508	3,277	20	115,286	19,878,477	19,671	112,148	16,800	134
1913....	......	......	......	......	......	......	9,653	......	......	......
1914....	......	......	......	......	......	17,637,149	......	89,140	......	......
1915....	......	......	......	......	......	19,693,599	......	126,127	......	......

Year.	Cobalt Ore.	Iron. Ore.	Iron. Pig.	Iron. Iron and Steel, Mfrs.	Iron. Sulphate.	Iron. Oxide.	Kaolin.	Lead. Ore.	Lead. Carbonate.	Lead. Pig, Scrap, and Mfrs.
1900....	......	2,119,003	(*b*)	118,152	1,589	1,022	39,842	19,772	1,739	70,857
1901....	......	1,662,875	(*b*)	77,742	45	1,001	41,972	15,430	1,789	59,051
1902....	......	1,563,334	149,755	60,697	17	1,051	41,165	13,121	2,223	58,694
1903....	......	1,832,820	61,085	119,799	36	1,207	47,534	20,172	2,040	75,416
1904....	......	1,738,514	38,521	125,709	319	1,151	50,465	25,731	2,221	76,198
1905....	......	2,151,954	121,726	150,480	709	1,330	52,603	35,103	2,306	73,938
1906....	......	2,015,550	135,252	342,411	132	1,311	44,772	43,137	2,072	67,651
1907....	1,396	1,999,000	122,102	336,337	......	......	53,447	42,342	......	53,359
1908....	1,500	1,454,000	156,618	373,624	......	......	58,909	40,700	......	70,824
1909....	400	1,202,619	154,031	354,428	......	......	59,490	38,400	......	68,332
1910....	2.6	1,318,520	168,810	378,227	2,243	1,235	62,920	28,950	3,259	64,517
1911....	0.3	1,350,794	194,225	77,000	4,454	1,511	66,500	47,340	3,095	69,791
1912....	......	1,454,190	36,637	114,100	2,800	1,466	63,783	42,499	2,919	65,449
1913....	......	......	49,612	......	......	......	61,255	39,772	......	......
1914....	......	1,044,160	57,241	......	......	......	......	......	......	41,900
1915....	......	397,348	......	......	......	......	......	......	......	51,700

Year.	Lime, Chloride of.	Manganese Ore.	Nickel.		Petroleum.	Phosphate Rock.	Platinum *Kg.*	Potassium.	
			Ore.	Metal.				Chloride.	Chromate. (*h*)
1900	1,215	120,790	17,687	299	302,482	283,921	2,398	13,524	3,293
1901	1,400	94,365	39,497	252	225,962	275,285	1,857	13,299	2,784
1902	2,130	85,629	58,374	301	148,170	302,898	2,940	10,802	2,861
1903	919	109,930	13,933	427	(*g*)476,230	343,012	3,764	12,275	2,760
1904	1,679	105,652	20,698	313	(*g*)435,730	419,720	5,650	14,734	2,618
1905	406	140,871	49,698	632	(*g*)512,727	447,738	4,023	21,819	2,619
1906	593	127,235	44,960	480	(*g*)213,462	533,213	5,708	26,523	3,024
1907	......	192,448	45,892	979	(*g*)311,000	636,549	4,373	......	......
1908(*k*)..	......	170,500	42,200	1,281	(*g*)300,000	767,424	3,955	......	......
1909(*k*)..	......	177,314	12,200	......	(*g*)300,000	645,178	5,914	......	......
1910	333	188,292	28,001	2,074	(*g*)271,500	687,675	7,795	34,974	3,009
1911	53	235,400	43,014	6,465	(*g*)375,000	740,375	9,392	39,508	2,991
1912	24	225,379	27,126	5,032	(*g*)360,000	903,490	6,236	45,174	3,178
1913	......	258,929	10,292	......	......	934,679	......	......	......
1914	......	......	......	3,174	(*g*)488,555	661,429	......	......	......
1915	......	......	......	3,892	(*g*)480,392	325,114	......	......	......

Year.	Potassium (*Cont'd*).		Pyrite.	Quicksilver.		Sal Ammoniac.	Salt.	Sodium.	
	Nitrate.	Carbonate.		Ore.	Metal.			Hydrate.	Nitrate.
1901	757	2,520	205,617	23	205	9,268	32,347	869	10,526,400
1902	1,547	1,539	170,783	24	224	15,446	32,505	643	9,372,600
1903	1,530	3,019	205,322	20	220	12,462	48,556	781	10,810,775
1904	2,117	3,781	230,097	22	208	13,744	46,232	1,068	9,074,859
1905	1,022	3,542	271,684	......	228	11,639	45,241	860	11,336,752
1906	684	2,206	349,514	......	242	18,146	38,361	614	13,678,848
1907	......	......	355,300	......	216	......	30,000	......	......
1908(*k*) .	......	......	348,300	......	180	......	33,000	......	......
1909(*k*) .	......	......	275,600	......	191	......	30,000	......	......
1910	132	2,579	309,400	......	146	27,860	49,800	577	345,160
1911	174	4,452	318,530	......	196	23,200	47,200	550	317,725
1912	53	4,017	486,072	......	213	25,056	39,500	556	354,776
1913	......	......	186,348	......	......	......	......	......	322,115
1914	......	......	......	......	......	......	......	......	297,190
1915	......	......	......	......	......	......	......	......	254,008

Year.	Sulphur.	Sulphuric Acid.	Superphosphate of Lime.	Tin.		Zinc.	
				Ore.	Metal.	Ore.	Metal.
1901..............	101,301	5,386	165,361	365	7,314	74,553	29,812
1902..............	85,839	7,793	116,093	748	8,575	69,451	36,564
1903..............	109,594	13,241	89,229	1,808	9,873	67,258	39,305
1904..............	148,547	11,212	72,921	1,344	9,352	88,083	35,737
1905..............	129,877	10,915	31,729	1,362	9,898	105,069	29,163
1906..............	131,678	5,268	44,502	1,038	7,687	106,307	26,960
1907..............	106,050	......	......	961	7,693	114,699	33,503
1908(*k*)...........	195,000	......	......	1,000	8,482	137,900	40,312
1909(*k*)...........	196,300	......	......	1,900	9,683	120,600	32,749
1910..............	202,263	14,642	132,530	1,651	8,517	193,360	19,237
1911..............	267,969	15,150	79,385	2,544	8,456	160,180	42,785
1912..............	172,181	13,169	89,059	1,726	8,503	158,429	43,795
1913..............	8,250	......	100,882	2,542	......	178,719	......
1914..............	116,018	......	231,265	......	7,216	......	30,361
1915..............	102,757	......	43,144	......	9,003	......	36,125

MINERAL AND METALLURGICAL EXPORTS OF FRANCE (*a*) (*k*)
(In metric tons)

Year.	Alu-minium.	Antimony.		Arsenic.	Cement.	Coal.	Copper.		Gold. *Kg.*(*d*)
		Ore.	Metal.				Ore. (*c*)	Metal.	
1900	324	154	336	…	232,577	1,201,210	9,197	16,791	883
1901	307	645	741	…	242,010	908,583	16,066	14,776	1,869
1902	748	595	666	…	210,590	910,760	20,489	14,423	1,517
1903	666	904	1,358	…	233,835	2,238,735	12,487	11,403	3,139
1904	664	1,191	720	…	260,686	2,384,928	14,258	12,663	1,537
1905	928	981	815	…	275,503	(*i*)3,348,010	13,260	13,800	5,740
1906	1,522	3,541	871	…	329,879	(*i*)1,448,000	8,056	6,130	11,727
1907	1,118	3,460	1,270	…	366,624	(*i*)1,224,000	4,151	18,630	6,289
1908	1,332	3,300	2,129	8,600	342,131	(*i*)1,117,000	3,600	17,845	4,455
1909	4,425	4,000	2,408	3,267	316,486	(*i*)1,493,308	6,200	18,775	5,366
1910	4,148	4,583	2,163	2,411	315,020	(*i*)1,580,077	4,163	20,884	7,264
1911	4,058	3,991	1,945	832	333,043	(*i*)1,635,000	8,335	22,690	…
1912	6,605	1,673	2,890	1,497	361,425	(*i*)2,320,349	6,374	42,307	775
1913	…	608	…	1,850	…	…	10,154	…	…
1914	…	…	…	…	…	913,432	…	…	…
1915	…	…	…	…	…	239,905	…	…	…

Year.	Iron.				Lead.		Man-ganese Ore.
	Ore.	Pig.	Bars.	Steel.	Ore.	Metal.	
1900	371,799	114,361	18,763	19,535	2,345	958	8,392
1901	258,925	96,463	25,220	56,347	3,490	718	5,289
1902	422,677	213,081	23,828	121,932	2,414	648	1,948
1903	714,173	196,444	40,533	215,737	2,313	13,048	717
1904	1,219,149	191,819	40,374	246,738	1,860	13,467	1,392
1905	1,355,932	218,227	67,240	343,612	3,064	12,903	662
1906	1,759,443	143,142	58,826	236,617	1,354	997	4,103
1907	2,147,000	249,708	84,557	291,434	1,210	1,912	5,167
1908	2,384,000	171,797	86,691	360,509	6,700	1,974	1,000
1909	3,907,338	161,058	96,999	318,925	2,800	2,458	1,149
1910	4,892,542	110,086	122,543	(*k*)302,168	5,855	3,004	722
1911	6,160,100	104,350	171,000	100,000	9,691	2,660	902
1912	8,318,312	216,895	67,000	170,000	12,276	1,660	2,282
1913	…	…	…	…	14,263	…	1,705
1914	4,828,592	…	…	…	…	…	…
1915	94,864	…	…	…	…	…	…

Year.	Nickel, Refined.	Phos-phate Rock.	Plaster.	Pyrite.	Silver. *Kg.* (*e*)	Tin (Metal).	Zinc.	
							Ore.	Spelter, Sheets and Scrap.
1901	1,031	81,405	101,063	52,952	16,745	438	42,995	15,022
1902	397	62,375	110,270	63,920	17,184	654	47,724	16,158
1903	720	72,252	131,245	119,173	43,690	1,994	62,731	12,657
1904	906	78,612	139,551	40,833	23,105	2,300	57,780	19,063
1905	1,583	55,240	124,561	21,257	66,904	2,611	72,512	17,802
1906	1,088	81,660	142,339	26,216	87,952	601	67,258	19,607
1907	1,414	100,508	137,356	24,417	58,199	729	54,316	21,928
1908	1,230	71,509	132,924	40,300	56,957	810	57,800	20,589
1909	1,940	47,611	120,701	40,200	56,549	886	60,000	24,729
1910	2,050	44,384	152,390	56,735	58,294	1,224	56,800	22,975
1911	880	31,413	148,952	68,919	17,256	1,520	51,737	25,500
1912	1,192	22,062	174,486	43,905	3,856	1,450	60,007	34,124
1913	…	21,128	…	…	…	…	58,203	…
1914	…	…	…	…	…	…	…	…
1915	…	…	…	…	…	…	…	…

(*a*) From *L'Economiste Francais* (representing the *Commerce Spécial*), except for 1903-06, inclusive, which are from *Tableau Général du Commerce et de la Navigation.* (*b*) Not reported. (*c*) Includes matte. (*d*) Gold and platinum in sheets, leaves, threads or jewelry, and crude platinum. (*e*) Silver in sheets, leaves, wire, and jewelry. (*f*) Includes bitumen, bituminous schist and sand, and asphaltic limestone. (*g*) Crude and refined. Transposition from hectoliters to tons was performed by assuming specific gravity of petroleum to be 0.9. (*h*) Includes chromate of soda. (*i*) Includes coke. (*k*) From *Statistique de l'Industrie Minérale* in the years 1908, 1909, 1910. Steel in 1910 not classified as before. 1911, from *l'Echo des Mines et Metallurgie.*

GERMANY

The mineral production and foreign commerce of the German Empire are given in the following tables in metric tons unless otherwise specified, or in dollars, on the basis of four marks to the dollar. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF GERMANY (*a*)

Year.	Alum.	Aluminium, Sulphate	Arsenic.		Asphaltum.	Boracite.	Cadmium. *Kg.*	Coal.	
			Ore.	Salts.				Bituminous.	Lignitic.
1900	4,355	44,372	4,379	2,415	89,685	232	13,553	109,290,237	40,498,019
1901	4,145	46,807	4,035	2,549	90,193	184	13,144	108,539,444	44,479,970
1902	4,108	47,905	3,959	2,828	88,374	196	12,625	107,473,933	43,126,281
1903	3,934	49,727	4,369	2,768	87,454	159	16,565	116,637,765	45,819,488
1904	3,850	55,881	4,390	2,829	91,736	135	25,245	120,815,503	48,635,080
1905	4,127	52,892	4,913	2,535	103,006	183	24,568	121,298,607	52,512,062
1906	4,494	55,969	6,249	3,052	117,413	161	21,486	137,117,926	56,419,567
1907	4,200	59,473	4,878	2,904	126,649	114	32,949	143,185,691	62,546,671
1908	3,802	53,958	6,065	2,822	89,009	128	32,995	147,671,149	67,615,200
1909	4,179	56,096	6,150	2,911	77,537	149	37,187	148,788,050	68,657,606
1910	4,406	58,349	6,151	3,066	81,208	167	41,100	152,827,777	69,473,883
1911	3,076	....	4,859	2,981	81,902	160	42,000	160,747,580	73,760,867
1912	....	....	4,869	....	96,117	224	43,000	174,875,297	80,934,797
1913	....	....	....	....	....	....	....	**191,511,000**	**87,475,000**

Year.	Cobalt, Nickel, and Bismuth Ores.	Copper.				Gold.	Graphite.
		Ore.	Matte. (*b*)	Ingots.	Sulphate.		
1899	1,270	733,619	95	34,634	5,142	$1,731,153	5,196
1900	4,495	747,749	4,207	30,929	5,076	2,030,200	9,248
1901	10,479	777,339	365	31,317	5,192	1,830,835	4,435
1902	12,433	761,921	447	30,578	4,997	1,770,361	5,023
1903	14,607	772,695	583	31,214	5,200	1,709,223	3,720
1904	14,016	798,214	641	30,264	6,584	1,819,538	3,784
1905	10,848	793,488	1,635	31,713	6,988	2,611,812	4,921
1906	....	768,523	771	32,275	6,757	2,931,750	4,055
1907	2,809	771,227	527	31,946	5,284	3,111,379	4,033
1908	8,535	727,384	328	30,001	7,117	3,162,544	4,844
1909	10,388	798,618	2,242	31,126	6,211	3,366,986	6,774
1910	10,313	925,957	3,735	34,926	5,210	3,227,250	7,415
1911	....	868,600	1,142	37,452	7,353	3,302,300	11,298
1912	12,861	969,330	2,574	49,447	5,955	**3,322,700**	12,532

Year.	Iron and Steel.				Lead.		
	Iron Ore.	Pig Iron. (*c*)	Wrought Iron and Steel.	Sulphate. (*d*)	Ore.	Pig.	Litharge.
1899	17,989,635	8,153,133	7,532,524	10,931	144,370	129,225	3,562
1900	18,964,294	8,520,540	7,377,275	10,913	148,257	121,513	3,088
1901	16,570,182	7,880,087	7,033,438	11,148	153,341	123,098	4,101
1902	17,963,591	8,529,900	8,317,231	....	167,855	140,331	4,197
1903	21,230,650	10,017,901	9,226,898	12,243	165,991	145,319	4,428
1904	22,047,393	10,058,273	9,239,302	13,585	164,440	137,580	4,332
1905	23,444,073	10,875,061	10,309,690	12,949	152,725	152,590	3,786
1906	26,734,570	12,292,819	11,307,807	13,376	140,914	150,741	4,137
1907	27,697,127	12,875,159	12,063,632	14,033	147,272	142,271	4,325
1908	24,278,151	11,805,321	10,930,933	15,738	156,861	164,079	5,339
1909	25,505,409	12,917,653	11,719,239	21,838	159,852	167,920	3,059
1910	28,709,700	14,502,183	12,988,177	18,677	148,497	159,851	3,581
1911	29,879,361	15,280,527	14,384,271	17,002	140,154	161,287	3,687
1912	27,199,944	15,220,881	16,508,987	....	142,839	192,618	4,135

Year.	Magnesium Salts.		Manganese Ore.	Petroleum.	Potassium Salts.				
	Chloride.	Sulphate.			Chloride.	Kainite. (*f*)	Sulphate.	Potassium-Magnesium Sulphate.	Other than Kainite.
1899 ...	21,370	39,540	61,329	27,027	207,506	1,108,159	26,103	9,765	1,384,972
1900 ...	19,397	48,591	59,204	50,375	271,512	1,227,873	30,853	15,368	1,822,758
1901 ...	21,018	46,714	56,691	44,095	294,666	1,498,569	37,394	15,612	2,036,325
1902 ...	19,658	39,262	49,812	49,725	267,512	1,322,623	28,278	18,147	1,962,384
1903 ...	22,990	37,844	47,994	62,680	280,248	1,557,243	36,674	23,631	2,073,720
1904 ...	25,730	39,412	52,886	89,620	297,238	1,905,893	43,959	29,285	2,179,471
1905 ...	29,017	58,568	51,463	78,869	373,177	2,387,643	47,994	34,222	2,655,845
1906 ...	38,468	43,041	52,485	81,350	403,387	2,720,594	54,490	35,211	2,821,073
1907 ...	32,891	41,105	73,105	106,379	473,138	2,624,412	60,292	33,368	3,124,955
1908 ...	29,775	42,977	67,692	141,900	511,258	2,715,487	55,756	33,149	3,383,535
1909 ...	31,526	53,812	77,177	143,244	624,994	3,181,349	68,539	38,722	3,969,554
1910 ...	32,207	57,314	80,560	145,168	741,259	4,249,667	84,583	37,438	4,062,004
1911 ...	36,764	55,179	87,297	142,992	838,420	4,425,497	107,631	42,253	5,181,379
1912 ...	85,387	99,442	185	134,986	506,744	5,889,238	123,407	54,435	....

Year.	Pyrite.	Salt.		Silver and Gold Ore.	Silver. *Kg.*	Sodium Sulphate.	Sulphur.	Sulphuric Acid.
		Rock.	Evaporated.					
1899....	144,623	861,123	571,058	13,506	467,590	79,062	1,663	813,141
1900....	169,447	926,563	587,464	12,593	415,735	90,468	1,445	829,376
1901....	157,433	985,050	578,751	11,577	403,796	76,066	963	835,000
1902....	165,225	1,010,412	572,846	11,724	430,610	90,742	....	894,409
1903....	170,867	1,095,541	598,394	11,467	396,253	83,087	219	928,190
1904....	174,782	1,079,868	621,064	10,405	389,827	75,171	209	963,384
1905....	185,368	1,165,495	612,062	10,286	399,775	68,454	205	1,228,211
1906....	196,971	1,235,041	635,171	8,066	393,442	81,175	178	1,335,128
1907....	196,351	1,285,137	665,547	8,280	386,933	80,347	176	1,402,398
1908....	219.456	1,331,984	665,651	7,653	407,185	72,667	811	1,391,653
1909....	198,688	1,370,668	647,939	7,510	400,562	71,813	1,185	1,434,709
1910....	215,708	1,424,064	669,120	6,646	420,003	84,787	1,272	1,616,336
1911....	217,459	1,436,492	645,991	4,890	439,580	82,664	1,251	1,534,455
1912....	242,121	1,352,524	671,622	595	....	....	....	1,649,681

Year.	Tin.			Uranium and Tungsten Ores.	Zinc.		
	Ore.	Block.	Chloride.		Ore.	Spelter.	Sulphate.
1900	80	2,031	(*g*) 143	43	639,215	155,790	6,027
1901	82	1,464	(*g*) 135	43	647,496	166,283	5,552
1902	104	2,779	....	31	702,504	174,927	....
1903	110	3,065	1,064	35	682,853	182,548	5,994
1904	99	4,216	816	23	715,732	193,058	6,185
1905	123	5,233	811	26	731,271	198,208	5,896
1906	....	6,597	987	....	704,590	205,691	6,092
1907	....	5,838	1,812	3	698,425	208,195	5,145
1908	111	6,374	2,266	42	706,441	216,490	5,310
1909	124	8,994	3,247	98	723,565	219,766	5,574
1910	125	11,395	3,391	95	718,316	221,395	6,308
1911	....	12,412	3,749	....	699,970	235,776	6,703
1912	(*i*)	10,646	3,094	70	643,598	269,161	6,413
1913	....	....	....	....	637,308	**283,190**	....

(*a*) From the *Vierteljahrshefte zur Statistik des Deutschen Reichs.* Where gold is reported, 1 mark = $0.238. (*b*) Includes black copper. (*c*) Includes ferro manganese and spiegeleisen. (*d*) Contains a small quantity of copper and iron sulphate mixed. (*f*) Compound of potassium chloride and magnesium sulphate. (*g*) Includes nickel sulphate. (*i*) Included with cobalt, nickel and bismuth.

MINERAL PRODUCTION OF BADEN (*a*)
(In metric tons or dollars; 4 marks = $1)

Year.	Aluminium Sulphate.	Barytes.	Coal.	Gypsum.	Manufacturers of Iron.		
					Cast, Foundry.	Steel.	Wrought.
1899....	2,153	2,430	4,700	29,419	53,608	3,830	1,402
1900....	2,286	2,970	4,930	26,381	50,102	3,532	1,364
1901....	2,260	3,991	3,650	28,183	40,100	8,739	1,158
1902....	2,374	6,234	2,078	33,150	40,973	12,663	1,052
1903....	2,498	8,857	1,990	29,423	45,233	7,666	863
1904....	2,392	9,078	1,485	26,984	64,320	7,687	783
1905....	2,581	11,094	668	28,823	74,128	8,053	842
1906....	2,583	11,984	1,000	25,643	81,387	11,068	466
1907....	2,644	9,303	2,075	29,153	98,430	10,818	533
1908....	2,524	(*c*) 8,554	2,473	35,217	83,724	10,430	602
1909....	2,329	(*c*) 15,186	2,356	36,621	83,458	11,643	484
1910....	2,141	(*c*) 13,832	1,650	41,078	95,795	12,134	239
1911....	2,554	15,014	(*b*)	42,408	107,784	11,909	244
1912....	....	15,871	....	51,778	....	....	....
1913....	....	16,445	....	49,767	....	....	....

Year.	Lead Ores.	Salt.	Sulphuric Acid.	Tripoli.	Zinc Ore.
1899..................	(*b*)	31,197	13,660	12	357
1900..................	67	32,699	15,938	9	3,004
1901..................	369	32,835	17,081	8	2,870
1902..................	450	32,192	19,265	11	2,958
1903..................	350	32,383	19,755	11	3,171
1904..................	265	32,148	35,517	12	5,063
1905..................	264	31,393	40,781	12	4,046
1906..................	246	31,288	38,655	15	1,466
1907..................	278	32,078	42,831	25	2,198
1908..................	329	33,993	41,455	13	2,793
1909..................	372	34,040	42,219	14	3,253
1910..................	419	32,729	56,069	7	3,345
1911..................	191	32,118	47,796	14	3,067
1912..................	428	32,326	....	14	3,730
1913..................	480	33,502	....	13	3,882

(*a*) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Badschen Staate.* (*b*) Not reported. (*c*) Includes fluorspar.

MINERAL PRODUCTION OF BAVARIA (*a*)
(In metric tons; 4 marks = $1)

Year.	Barytes.	Kaolin.	Coal.	Coal (Lignite).	Copperas and Other Sulphate.	Emery.	Feldspar.	Fluorspar.	Graphite.
1899..	6,214	25,822	1,004,421	35,736	900	399	287	3,631	5,196
1900..	10,515	58,795	1,185,296	39,165	916	414	460	7,456	9,248
1901..	8,711	35,450	1,203,792	25,224	590	366	788	5,220	4,435
1902..	8,034	92,073	1,233,568	27,337	691	225	447	5,460	5,023
1903..	8,642	88,140	1,356,556	25,189	814	220	1,060	3,410	3,719
1904..	9,411	95,160	1,341,925	53,517	893	265	1,866	4,770	3,784
1905..	10,030	99,910	1,317,951	154,128	844	255	1,710	4,413	4,921
1906..	19,817	98,138	1,381,175	140,290	836	320	1,740	5,570	4,055
1907..	21,500	115,387	1,495,895	286,256	850	326	2,125	4,780	4,033
1908..	17,195	68,551	647,639	1,209,110	910	245	5,859	5,480	4,844
1909..	17,920	187,312	694,191	1,242,088	1,094	305	3,151	5,580	6,774
1910..	24,711	107,660	713,994	1,299,970	1,333	270	2,620	5,132	7,415
1911..	26,234	70,512	763,172	1,548,465	....	210	3,165	4,680	11,298
1912..	27,199	72,517	790,680	1,704,654	....	260	6,666	4,220	12,532
1913..	....	....	**811,000**	**1,895,000**	....	......	....	....	....

Year.	Gypsum.	Iron.						Lithographic Limestone.
		Ore.	Bar.	Cast, 1st Fusion.	Cast, 2d Fusion.	Pig.	Steel.	
1899....	29,727	181,981	61,415	(*b*)	92,459	83,821	134,007	11,962
1900....	35,484	178,441	49,727	29	89,692	82,327	135,411	16,030
1901....	3,581	158,820	29,978	76	76,191	72,071	109,464	9,500
1902....	31,701	157,375	38,429	56	81,874	83,123	115,354	....
1903....	30,894	162,500	36,853	41	89,804	90,168	127,141	9,890
1904....	22,766	180,342	37,780	40	108,025	92,200	125,483	13,836
1905....	46,247	182,389	36,459	24	112,875	94,242	134,755	11,360
1906....	50,763	203,596	38,508	....	122,115	97,812	150,129	....
1907....	48,975	277,280	36,883	*Nil.*	138,659	98,143	150,148	11,590
1908....	51,314	278,681	30,740	*Nil.*	128,234	131,404	176,085	9,858
1909....	51,630	279,514	33,448	*Nil.*	130,129	134,133	219,606	9,420
1910....	54,397	303,844	30,881	*Nil.*	148,261	133,679	249,198	9,790
1911....	60,390	375,409	165,683	*Nil.*	171,976	....	339,401	8,175
1912....	57,114	450,074	(*c*)	....	396,656	195,606	998,624	9,903

Year.	Marl. (For Cement)	Mineral Paint and Chalk.	Pyrites.	Rock Salt.	Soapstone.	Sodium Sulphate.	Sulphuric Acid.
1899....	220,716	9,287	2,516	802	2,197	1,570	123,273
1900....	180,032	11,507	2,120	1,298	1,977	1,821	123,910
1901....	76,663	84,929	2,649	1,319	2,291	1,893	115,775
1902....	178,301	13,947	2,635	832	......	....	....
1903....	200,407	19,486	2,324	879	1,866	....	....
1904....	170,698	19,107	3,427	1,139	1,709	....	....
1905....	231,310	18,285	3,301	911	1,872	....	....
1906....	230,271	22,304	3,918	1,053	......	....	....
1907....	230,583	21,219	5,085	1,393	1,999	1,439	161,868
1908....	307,820	21,310	4,037	1,285	2,199	1,743	149,079
1909....	276,974	21,692	2,952	1,860	2,329	1,265	178,371
1910....	273,727	22,357	4,466	1,192	3,083	1,416	171,131
1911....	265,899	24,258	6,316	782	3,431	2,061	170,039
1912....	341,068	30,033	6,531	1,162	3,221	....	254,708

(*a*) From the *Uebersicht der Production des Bergwerks-, Hütten-, und Salinen-Betriebes in dem Bayerischen Staate.* (*b*) Not reported. (*c*) With cast iron.

MINERAL PRODUCTION OF PRUSSIA (*a*)

(Metric tons; 4 marks = $1)

Year.	Alum Shale.	Antimony and Alloys.	Arsenic Products.	Arsenic Ore.	Asphalt.	Boracite.	Cadmium. *Kg.*	Coal.
1900....	103	3,025	1,585	3,531	23,891	217	13,533	101,966,158
1901....	611	2,404	1,446	3,050	26,450	164	13,144	101,203,807
1902....	219	3,542	1,514	2,909	28,035	172	12,625	100,115,315
1903....	580	3,224	1,583	3,538	23,518	135	16,565	108,809,384
1904....	106	2,774	1,573	3,527	26,348	115	25,245	112,755,621
1905....	97	2,795	1,493	4,022	28,872	151	24,568	113,000,657
1906....	634	2,953	1,551	5,430	32,270	124	21,486	128,295,948
1907....	154	3,515	1,591	4,224	39,243	90	32,949	134,044,080
1908....	80	3,596	1,646	5,015	27,444	105	32,995	139,002,378
1909....	60	3,841	1,849	5,731	19,509	123	37,187	139,906,194
1910....	46	4,969	2,068	5,789	21,595	138	41,058	143,771,612
1911....	63	5,411	1,862	4,476	19,956	147	42,575	151,324,030
1912....	104	....	....	4,870	21,241	186	....	165,302,784
1913....	180	....	....	5,008	17,795	160	....	179,861,015

Year.	Coal (Lignite).	Cobalt Ore.	Cobalt Products.	Copper.	Copper and Iron Sulphate.	Copper Ore.	Copper Matte.
1900....	34,007,542	4	52	27,156	113	747,601	4,207
1901....	37,491,412	36	66	28,422	78	765,241	281
1902....	36,228,285	76	74	27,893	119	751,496	346
1903....	38,462,766	65	87	28,386	110	761,188	488
1904....	41,153,576	41	85	27,450	95	782,049	601
1905....	44,148,751	22	99	28,874	102	769,381	1,052
1906....	47,912,721	7	98	29,166	94	755,812	525
1907....	52,660,597	*Nil.*	109	28,945	64	755,203	499
1908....	55,456,860	*Nil.*	100	27,301	50	711,921	296
1909....	56,029,554	*Nil.*	93	28,523	55	798,448	1,935
1910....	56,644,291	*Nil.*	94	30,244	44	914,519	2,060
1911....	60,531,943	*Nil.*	107	30,986	27	919,827	996
1912....	65,803,959	*Nil.*	....	....	....	967,785	....
1913....	70,051,871	*Nil.*	....	....	....	941,402	....

Year.	Copper Sulphate.	Epsom Salt.	Gold. *Kg.*	Iron.	Iron Ore.	Iron Sulphate.	Lead.
1900......	1,660	1,511	1,076.6	5,781,892	4,268,069	10,225	112,738
1901......	1,951	1,952	1,087.1	5,315,628	3,831,670	10,239	113,939
1902......	1,937	761	1,138.0	5,633,089	3,362,887	11,214	127,283
1903......	2,254	421	949.5	6,614,768	3,786,743	11,086	133,405
1904......	3,364	289	1,081.9	6,573,507	3,757,651	12,524	128,294
1905......	3,065	338	1,034.9	7,106,975	4,130,210	12,075	143,270
1906......	2,724	144	750.2	8,154,880	4,713,928	12,473	140,690
1907......	2,129	263	771.0	8,266,300	5,077,773	13,014	132,366
1908......	3,116	398	786.6	7,989,260	4,311,593	14,062	153,541
1909......	2,500	395	588.2	8,410,824	4,389,950	18,295	156,533
1910......	1,749	162	566.3	9,995,012	4,823,606	16,119	146,993
1911....	2,464	114	520.	10,477,263	4,948,711	15,468	147,538
1912......	....	....	....	....	5,331,240	....	....
1913......	....	....	....	....	5,461,670	....	....

Year.	Lead Ore.	Litharge.	Manganese Ore.	Nickel.	Nickel Ore.	Nickel Sulphate.	Ocher and Mineral Paints.
1900........	133,483	2,366	58,016	1,376	3,896	115	2,850
1901........	139,285	2,885	55,866	1,660	9,922	120	2,800
1902........	152,282	2,516	48,882	1,605	11,816	159	2,780
1903........	151,746	2,710	47,110	1,945	14,058	173	2,850
1904........	150,328	2,517	52,092	2,333	13,518	207	3,200
1905........	138,928	2,272	51,048	2,631	10,432	220	3,170
1906........	127,322	2,744	51,881	2,648	7,472	187	3,635
1907........	133,528	2,959	72,442	2,093	7,557	189	3,707
1908........	141,316	4,190	67,241	2,622	8,238	181	3,183
1909........	158,811	2,365	76,741	3,186	10,095	163	3,435
1910........	146,830	3,076	80,325	3,497	10,053	213	142
1911........	135,366	3,441	86,902	3,744	9,609	244	....
1912........	140,158	....	92,474	....	12,091	....	....
1913........	143,799	....	(*b*)	....	13,538	....	....

Year.	Petroleum.	Potassium Salts.		Pyrite.	Quick-silver. *Kg.*	Salt.	
		Kainite.	All Other.			Common.	Rock.
1900......	27,731	857,271	1,264,993	159,186	1,711	287,005	354,603
1901......	24,098	1,068,237	1,131,703	148,457	1,713	290,869	353,557
1902......	29,520	943,450	1,344,541	155,410	1,828	291,296	359,006
1903......	41,733	1,118,270	1,344,038	159,234	2,145	317,475	409,199
1904......	67,604	1,261,930	1,447,323	163,209	3,030	328,933	394,910
1905......	57,741	1,580,530	1,734,033	174,641	2,597	328,051	436,942
1906......	59,196	1,923,088	1,937,181	186,849	5,084	339,675	492,339
1907.......	80,255	1,839,409	2,070,978	184,962	5,080	353,290	480,563
1908......	113,002	2,037,203	2,192,188	204,992	4,423	359,003	478,346
1909......	113,518	2,431,401	2,436,319	189,773	5,213	344,685	491,071
1910......	110,996	3,119,400	2,584,565	203,596	4,492	351,698	500,978
1911......	98,611	3,502,762	2,920,725	203,249	2,861	337,583	527,034
1912......	87,443	4,256,476	3,287,177	233,397	....	343,883	527,275
1913......	71,178	4,426,054	3,658,109	228,405	....	353,260	526,218

Year.	Silver. *Kg.*	Silver and Gold Ores.	Sulphur.	Sulphuric Acid.	Tin.	Zinc.		
						Ore.	Metal.	Sulphate.
1900......	266,577	1	1,207	593,109	2,010	636,068	155,760	3,742
1901.....	246,286	6	772	609,041	1,443	644,504	166,223	3,369
1902.....	273,901	17	250	677,798	2,753	699,392	174,892	3,381
1903.....	255,722	13	16	724,784	3,042	679,320	182,472	3,586
1904.....	252,020	8	16	868,424	4,193	710,599	192,903	3,696
1905.....	266,072	4	14	921,219	5,196	727,104	198,179	3,506
1906.....	264,427	239	16	980,188	6,570	702,933	205,632	3,630
1907.....	249,348	34	7	1,004,599	5,819	696,039	207,849	3,057
1908.....	274,154	7	706	997,931	5,330	703,394	212,991	3,223
1909.....	271,779	2	1,096	1,006,787	8,943	720,139	214,551	3,434
1910.....	277,777	0.2	1,239	1,164,015	11,345	714,855	216,362	3,875
1911.....	277,981	.....	1,239	1,219,879	12,335	696,903	230,995	4,127
1912.....	....	.....	....	....	......	647,081	....	....
1913.....	....	.....	....	....	......	649,695	....	....

(*a*) From *Zeitschrift für das Berg, Hütten, und Salinenwesen.*
(*b*) Included in " Iron Ore."

MINERAL IMPORTS OF GERMANY (*a*)

Year.	Aluminium Refined and Crude.	Ammonium Sulphate.	Antimony.	Antimony and Arsenic Ores.	Asbestos, Crude.	Asphalt.	Bituminous Rock.	Barium Chloride.	Barytes. (*b*)
1901 ...	1,090	44,408	1,494	1,098	5,500	62,299	41,733	1,768	5,764
1902 ...	1,100	42,252	1,495	1,231	3,415	88,536	36,791	2,135	5,040
1903 ...	1,155	35,168	2,281	1,741	5,727	94,377	40,873	2,374	5,534
1904 ...	2,422	35,166	2,003	1,687	5,251	85,049	38,812	2,428	6,742
1905 ...	3,252	48,005	1,680	567	7,830	3,461	64,196	2,114	7,981
1906 ...	3,886	35,366	2,044	2,417	9,828	15,095	118,238	2,559	17,246
1907 ...	3,974	33,522	2,496	4,913	11,096	4,793	128,257	2,781	12,588
1908 ...	3,204	47,265	2,670	2,073	10,034	2,587	130,063	2,256	19,969
1909 ...	8,696	58,132	2,719	2,912	11,928	1,209	98,378	1,907	14,560
1910 ...	9,892	31,400	2,982	3,347	11,729	2,932	117,763	1,955	5,782
1911 ...	10,454	24,463	3,607	6,429	12,334	133,635	17,476	2,002	7,926
1912 ...	18,112	23,098	3,400	2,891	14,790	147,784	18,409	3,674	18,666
1913 ...	15,508	34,627	3,604	3,700	14,658	145,351	....	2,598	19,466

Year.	Borax.	Bauxite.	Calcium Carbide.	Cement.	Chalk (*d*), Crude White.	Chrome Ore.	Coal.		Coke.
							Bitum., Arthracite, Cannel.	Lignitic.	
1901 ...	2,537	24,113	9,526	87,262	(*d*)29,611	18,222	6,297,389	8,108,943	400,197
1902 ...	2,057	26,698	11,287	52,018	(*d*)26,408	10,152	6,425,658	7,882,010	382,488
1903 ...	2,567	22,316	14,081	49,870	(*d*)33,362	13,919	6,766,513	7,962,123	432,819
1904 ...	2,603	27,849	14,840	60,188	(*d*)32,581	18,132	7,299,042	7,669,099	550,302
1905 ...	2,802	39,137	17,256	148,118	(*d*)35,529	11,998	9,399,693	7,945,261	713,619
1906 ...	3,044	43,177	22,819	233,119	18,871	17,124	9,253,711	8,430,441	565,561
1907 ...	2,014	59,989	25,834	241,475	16,035	19,508	13,729,849	8,963,103	584,220
1908 ...	1,903	48,064	29,024	168,504	17,606	16,974	11,661,503	8,581,966	575,091
1909 ...	2,550	45,543	26,956	224,178	15,924	22,018	12,198,634	8,166,479	673,012
1910 ...	3,181	56,287	30,712	242,663	17,700	24,470	11,195,593	7,397,719	622,452
1911 ...	5,358	37,155	36,994	253,023	23,717	16,022	10,913,948	7,069,064	598,958
1912 ...	7,978	36,348	47,984	228,896	28,031	23,201	10,380,482	7,266,116	589,713
1913 ...	7,381	38,452	46,725	168,449	32,546	23,251	10,540,018	6,986,681	592,661

Year.	Peat and Peat Coke.	Briquettes.	Cobalt and Nickel Ore.	Copper.				Copperas	Cryolite.
				Ore. and Matte.	Ingots.	Bars, Wire and Sheets.	Sulphate.		
1901 ...	15,102	92,037	12,186	4,614	58,620	786	1,211	501	1,249
1902 ...	16,696	81,854	14,630	14,630	76,050	540	2,499	807	1,332
1903 ...	14,640	84,635	36,927	13,714	83,261	568	1,691	778	1,082
1904 ...	9,071.	125,477	14,555	7,949	110,231	719	1,735	765	1,139
1905 ...	11,439	191,753	39,590	10,137	102,218	927	2,180	666	1,143
1906 ...	19,428	162,650	22,557	9,941	126,071	409	1,702	621	(*k*)
1907 ...	15,238	195,403	29,296	19,295	124,116	772	4,519	1,165	(*k*)
1908 ...	15,266	192,391	17,402	17,456	157,669	952	5,078	7,234	(*k*)
1909 ...	13,208	211,058	10,186	26,488	154,673	416	6,550	5,954	(*k*)
1910 ...	16,188	241,267	9,937	22,194	181,551	403	3,952	4,336	(*k*)
1911 ...	14,517	210,933	14,897	23,327	191,590	520	4,145	3,323	(*k*)
1912 ...	11,040	187,736	14,987	23,192	200,608	332	7,074	5,925	(*k*)
1913 ...	11,796	147,416	13,658	27,594	225,392	......	3,869	2,954	(*k*)

Year.	Gold, Silver and Platinum Ores.	Graphite	Gypsum.	Iodine.	Iron.		Lead.		
					Ore.	Pig.	Ore.	Pig and Scrap.	Lead White.
1901 ...	8,764	17,374	7,622	266	4,370,022	267,503	100,196	52,886	423
1902 ...	6,585	19,392	8,177	220	3,957,403	143,040	71,078	39,006	357
1903 ...	4,386	20,953	8,328	320	5,225,336	158,347	67,573	52,440	442
1904 ...	5,960	23,533	9,550	272	6,061,127	178,256	83,807	61,388	622
1905 ...	6,225	26,143	11,247	377	6,085,196	158,700	92,667	78,528	2,488
1906 ...	4,819	28,175	11,062	297	7,629,730	409,083	90,027	71,191	2,342
1907 ...	3,601	29,405	14,662	147	8,476,076	443,624	137,861	75,200	3,037
1908 ...	1,922	34,491	14,599	194	7,732,949	252,779	133,597	77,218	3,558
1909 ...	1,759	29,191	11,285	369	8,366,599	134,230	111,017	76,930	2,890
1910 ...	2,552	30,733	10,873	363	9,816,822	136,330	112,151	81,541	2,780
1911 ...	2,947	32,812	11,973	303	10,812,595	129,850	143,598	100,515	3,938
1912 ...	2,200	37,633	10,628	260	12,120,090	135,722	122,847	93,585	2,709
1913 ...	1,932	37,168	8,818	258	14,019,045	124,236	142,977	83,781	1,980

Year.	Magnesite.	Manganese Ore.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products		Phosphorus.
						Illuminating Oil.	Lubricating Oil.	
1901....	8,897	204,420	9,403	1,947	1,981	985,904	118,999	313
1902....	12,237	222,010	7,719	1,458	1,585	1,006,829	125,667	350
1903....	14,958	204,647	9,888	1,507	1,663	1,067,697	147,837	222
1904....	15,877	223,709	10,494	1,712	1,300	1,076,324	142,929	220
1905....	19,459	255,760	11,473	1,955	1,114	1,070,252	143,926	198
1906....	25,527	262,311	3,960	3,478	1,303	984,134	180,989	208
1907....	30,857	331,171	2,166	2,182	1,653	1,115,205	226,609	165
1908....	28,305	393,327	1,635	3,058	1,447	1,123,632	216,887	141
1909....	29,994	334,133	13,804	3,745	1,447	1,085,839	216,987	179
1910....	40,218	384,445	15,100	4,606	1,729	1,135,886	230,516	169
1911....	47,930	487,872	15.703	2,598	1,591	955,482	260,242	200
1912....	69,064	420.709	17,874	2,027	1,479	795,011	241,030	205
1913....	64,974	680,371	18,971	3,315	1,363	745,466	248,035	209

Year.	Phosphate Rock.	Potassium Salts.							Pumice Stone.(*g*)	Pyrite.
		Chloride.	Cyanide. (*f*)	Iodide.	Nitrate.	Carbonate.	Hydroxide.	Sulphate.		
1901....	351,155	462	2	1,529	1,758	1,529	165	680	2,336	488,633
1902....	430,043	261	3	10	1,889	2,112	42	266	2,070	482,095
1903....	461,092	40	3	8	2,163	1,850	52	81	2,697	519,317
1904....	508,634	47	2	10	2,349	1,955	61	121	3,000	503,503
1905....	501,048	223	3	30	2,156	1,693	24	131	3,240	552,184
1906....	531,195	181	3	18	1,918	2,099	44	257	5,463	579,355
1907....	579,505	1,615	1	8	1,815	2,304	92	141	5,443	742,526
1908....	736,127	49	4	7	2,200	1,773	50	169	6,154	659,871
1909....	663,400	55	2	4	2,853	1,750	64	101	6,639	691,213
1910....	723,271	72	2	8	1,979	2,366	63	66	7,446	792,735
1911....	831,027	1,160	33	13	2,114	2,616	67	61	9,659	862,214
1912....	902,844	46	5	11	597	2,321	62	44	8,365	1,073,285
1913....	928,798	15	3	13	402	2,760	42	44	8,801	1,023,952

Year.	Quicksilver.	Salt.	Slag and Slag Wool.	Sodium Salts.			Strontianite. (*n*)
				Soda, Calcined.	Nitrate (Chile Saltpeter).	Sulphate and Sulphite.	
1901	651	23,901	733,931	178	529,568	7,921	19,739
1902	648	26,404	831,282	121	467,024	7,308	34,035
1903	674	20,118	877,394	114	467,130	6,058	24,183
1904	691	18,743	846,738	179	506,172	9,598	18,055
1905	729	20,726	888,665	143	540,916	4,752	13,720
1906	698	16,997	813,388	189	593,218	7,405	5,212
1907	831	23,109	568,046	257	591,131	10,446	5,595
1908	648	24,975	562,853	293	604,457	4,404	4,211
1909	723	19,319	492,771	181	665,450	9,214	4,277
1910	836	30,443	766,320	105	749,945	9,302	4.852
1911	919	29,067	685,943	559	730,939	5,976	3,251
1912	990	17,887	1,248,693	1,987	812,898	5,609	4,259
1913	961	21,422	....	2,633	774,298	10,074	3,965

Year.	Sulphur.	Sulphuric Acid.	Super-phosphate.	Tin, Crude.	Zinc.			
					Ore.	Spelter.	Drawn or Rolled.	Zinc White, Zinc Gray, Lithophone.
1901....	32,750	18,502	107,365	12,910	75,533	21,250	306	3,673
1902....	32,798	22,205	109,374	13,760	61,407	25,946	134	3,986
1903....	41,545	13,418	82,740	13,925	67,156	25,749	237	4,667
1904....	41,030	16,087	91,288	14,352	93,515	26,389	151	6,461
1905....	39,989	33,837	109,666	13,501	126,577	29,583	54	7,802
1906....	41,390	74,536	76,384	14,098	178,953	39,314	97	9,140
1907....	44,700	59,753	62,877	12,814	184,703	28,459	134	10,189
1908....	44,066	61,391	71,879	14,039	199,840	32,622	286	7,080
1909....	42,941	74,384	80,512	13,537	201,110	44,514	99	7,002
1910....	46,796	86,743	78,873	14,297	240,584	39,328	246	9,239
1911....	46,054	99,653	71,119	14,500	262,399	48,355	467	7,697
1912....	42,284	98,573	62,400	15,550	293,090	56,937	1,003	9,367
1913....	46,737	130,257	53,193	14,261	313,269	57,641	725	9,108

MINERAL EXPORTS OF GERMANY (*a*)

Year.	Aluminium Refined and Crude.	Aluminium Wares, etc.	Aluminium Sulphate.	Ammonium.		Antimony and Arsenic Ores.	Antimony.	
				Carbonate and Chloride.	Sulphate.		Metallic.	Salts.
1901....	282	2,270	31,171	3,196	9,842	283	76	826
1902....	410	2,608	34,005	3,351	5,744	410	105	954
1903....	353	2,865	28,513	2,778	5,592	427	83	873
1904....	407	3,077	29,311	3,106	10,696	486	250	964
1905....	1,192	3,476	34,776	3,579	27,589	287	218	1,097
1906....	1,111	1,321	25,937	3,555	37,288	548	221	997
1907....	1,119	1,142	24,759	3,118	57,439	930	255	1,168
1908....	590	642	22,376	1,161	73,186	588	146	1,030
1909....	492	1,273	58,723	1,093	58,722	577	160	1,090
1910....	616	1,755	93,069	1,500	93,069	571	198	1,047
1911....	768	1,331	30,107	4,895	74,410	612	298	1,208
1912....	2,074	4,184	32,469	5,292	57,268	569	132	1,155
1913....	2,703	5,667	31,772	5,401	75,868	502	702	1,461

Year.	Arsenic.		Asbestos.	Barytes. (*b*)	Barium.		Bauxite.	Borax.	Bromine.
	Metallic.	White, etc.	Crude.		Chloride and Salts of.	White.			
1901 ...	28	1,534	638	67,526	6,803	2,765	137	2,563	228
1902 ...	46	2,036	709	56,026	7,358	2,922	32	2,836	153
1903 ...	32	1,903	513	72,455	8,417	3,187	19	2,779	155
1904 ...	50	1,956	738	69,564	8,596	3,777	21	2,741	208
1905 ...	40	1,753	1,173	81,134	9,550	4,382	6	2,720	156
1906 ...	....	2,282	1,938	90,819	6,541	10,721	398	2,795	172
1907 ...	(*m*)45	1,733	1,707	111,209	4,189	8,454	517	3,049	118
1908 ...	(*m*)65	1,956	1,345	91,111	3,389	5,190	783	2,379	227
1909 ...	(*m*)54	1,012	1,740	90,555	5,340	4,888	1,116	2,735	206
1910 ...	(*m*)57	1,507	1,537	114,264	6,403	5,528	863	2,916	225
1911 ...	71	1,973	1,503	128,452	6,180	6,834	960	3,199	229
1912 ...	73	2,400	1,891	142,957	7,389	8,298	400	3,330	187
1913 ...	....	2,612	1,461	158,065	5,649	7,647	355	3,433	239

Year.	Coke.	Peat and Peat Coke.	Briquets.	Cobalt and Nickel Ore.	Copper.			
					Ore and Matte.	Bars, Sheets and Wire.	Ingots.	Sulphate.
1901....	2,096,931	11,588	529,765	96	26,678	7,700	5,097	1,942
1902 ..	2,182,383	13,410	697,799	3	17,031	10,599	4,678	1,366
1903....	2,523,351	16,986	895,145	1	15,986	10,715	4,333	1,880
1904....	2,716,855	14,830	917,526	83	19,235	12,594	4,223	2,231
1905....	2,761,080	16,009	936,694	107	28,908	10,006	5,958	2,180
1906....	3,415,347	15,680	1,095,029	(*i*)	6,414	10,728	7,241	3,018
1907....	3,792,580	25,746	1,260,135	(*i*)	20,950	13,411	6,113	2,016
1908....	3,577,496	26,817	1,493,054	(*i*)	21,729	17,209	6,868	2,994
1909....	3,444,791	23,579	1,620,460	(*i*)	22,437	15,395	6,495	1,290
1910....	4,125,898	20,360	1,988,177	(*i*)	23,751	19,351	7,654	2,108
1911....	4,555,477	35,855	2,477,492	(*i*)	27,396	19,669	7,106	3,346
1912....	5,850,350	60,557	2,746,536	(*i*)	21,514	20,245	7,854	3,812
1913....	6,411,418	86,920	3,163,742	(*i*)	25,221	....	7,208	4,013

Year.	Bromine Salts.	Calcium.		Cement.	Chalk, Crude White.	Chromium.		Coal.	
		Carbide.	Chloride.			Ore.	Alum.	Bituminous, Anthracite and Cannel.	Lignitic
1901 ...	249	275	888	560,612	(*d*)14,134	581	1,299	15,269,267	21,718
1902 ...	357	126	1,346	699,378	(*d*) 8,475	846	1,758	16,101,141	21,766
1903 ...	435	335	1,831	742,381	(*d*)12,211	37	1,921	17,389,934	22,499
1904 ...	411	608	2,381	635,248	(*d*)11,359	47	2,432	17,996,726	22,135
1905 ...	634	709	2,831	675,664	(*d*)13,081	43	2,507	18,156,998	20,118
1906 ...	643	545	(*l*)	736,579	4,287	(*h*) 36	2,942	19,550,964	18,759
1907 ...	655	918	(*l*)	692,982	2,919	(*h*) 149	3,110	20,056,503	22,065
1908 ...	506	844	(*l*)	528,847	2,108	(*h*) 110	3,215	21,190,777	27,877
1909 ...	486	968	(*l*)	611,893	4,395	(*h*)5,023	3,023	23,350,705	39,815
1910 ...	323	1,482	(*l*)	725,356	3,359	(*h*) 386	3,998	24,257,651	62,441
1911 ...	....	2,120	(*l*)	845,850	1,537	(*h*)1,795	2,815	27,412,218	58,071
1912 ...	372	971	(*l*)	1,056,622	2,890	(*h*) 778	3,221	31,145,057	56,966
1913 ...	405	....	(*l*)	1,129,563	3,409	(*h*) 681	3,313	34,573,514	60,345

Year.	Copperas.	Cryolite.	Fluorspar.	Graphite.	Gypsum.	Iodine.	Iron.	
							Ore.	Pig.
1901.......	4,125	367	13,436	1,667	40,397	27	2,389,870	150,448
1902.......	4,360	486	14,177	1,691	42,859	24	2,868,068	374,256
1903.......	3,986	349	13,028	1,810	51,874	29	3,343,510	418,072
1904.......	3,514	310	13,540	1,815	55,043	30	3,440,846	225,897
1905.......	4,495	286	15,019	1,971	52,886	27	3,698,563	380,824
1906.......	4,712	(*k*)	15,493	2,013	63,516	46	3,851,791	479,772
1907.......	6,212	(*k*)	16,624	2,176	70,737	44	3,904,400	275,170
1908.......	4,393	(*k*)	14,925	2,469	60,992	51	3,067,737	257,849
1909.......	2,232	(*k*)	14,534	2,377	63,220	59	2,825,007	471,045
1910.......	2,929	(*k*)	17,988	3,424	89,590	70	2,952,634	786,854
1911.......	4,151	(*k*)	23,073	3,822	102,754	73	2,581,698	829,393
1912.......	3,386	(*k*)	21,145	4,501	108,624	79	2,309,628	1,016,261
1913.......	5,382	(*k*)	25,523	5,423	132,693	92	2,613,158	782,911

Year.	Lead.					Lime, Chloride of.	Mag-nesite.	Magne-sium Chloride.	Manga-nese Ore.
	Ore.	Pig and Scrap.	Litharge.	White.	Red.				
1901 ...	891	20,820	4,876	16,966	7,776	32,705	2,485	16,102	5,584
1902 ...	2,024	23,100	4,072	19,070	8,372	29,694	2,955	14,757	4,528
1903 ...	1,270	30,243	5,175	20,765	7,617	28,849	2,812	17,008	11,138
1904 ...	1,312	23,169	5,410	16,638	7,544	30,078	1,917	16,706	5,536
1905 ...	1,496	32,515	4,466	16,478	8,902	30,667	2,552	21,673	4,116
1906 ...	1,915	27,067	2,493	14,022	9,450	29,485	2,843	26,708	2,555
1907 ...	1,296	38,259	4,470	13,651	9,371	24,946	3,264	29,566	3,554
1908 ...	1,189	29,967	5,242	13,733	9,602	23,895	4,021	27,525	2,333
1909 ...	2,556	31,674	4,750	10,583	9,058	27,314	3,702	31,334	4,488
1910 ...	2,382	31,025	4,865	13,595	10,444	24,716	5,399	35,352	4,557
1911 ...	3,746	32,063	5,436	14,962	11,321	27,107	4,496	43,896	9,615
1912 ...	3,273	38,122	6,480	12,750	10,116	32,254	7,132	39,559	7,790
1913 ...	4,458	41,369	6,203	12,402	8,898	36,473	5,857	55,505	9,388

Year.	Mineral Pigments.	Nickel.	Ozokerite.	Petroleum Products. (*f*)		Phosphor-us.	Phosphate Rock.
				Illuminating Oil.	Lubricating Oil.		
1901........	12,671	390	1,700	655	963	149	2,260
1902........	14,392	689	1,856	824	1,177	260	1,103
1903........	15,161	700	2.027	701	1,975	286	4,342
1904........	16,395	1,203	2,447	760	1,763	236	3,222
1905........	17,603	1,034	2,757	7,286	1,746	228	3,720
1906........	4,290	954	509	673	9,982	228	5,484
1907........	4,097	930	692	770	10,552	165	1,494
1908........	15,675	1,349	921	1,008	10,852	160	1,196
1909........	18,130	1,606	1,300	588	11,621	168	5,429
1910........	19,355	1,381	1,642	472	17,141	160	5,044
1911........	22,426	1,592	1,295	274	18,905	192	10,591
1912........	27,313	1,677	1,167	244	19,635	219	7,032
1913........	30,348	1,673	1,999	....	....	192	6,885

Year.	Potassium Salts.						Potassium and Potas-sium-mag-nesium Sulphate.	Pum-ice Stone. (*g*)	Pyrite.
	Carbonate	Cyanide. (*f*)	Chloride.	Hydroxide.	Iodide.	Nitrate.			
1901 ...	15,567	2,089	118,959	14,892	145	13,439	37,216	699	23,680
1902 ...	14,041	3,257	106,925	13,804	152	9,734	40,487	691	35,370
1903 ...	13,121	2,017	125,302	13,006	154	9,671	56,455	794	32,611
1904 ...	10,777	3,290	140,765	24,963	174	10,405	64,400	943	30,666
1905 ...	11,963	4,005	156,440	22,246	170	12,140	67,286	939	35,195
1906 ...	12,543	5,049	171,994	21,772	168	11,564	54,557	1,578	35,829
1907 ...	13,314	5,210	173,638	20,254	146	12,668	128,344	2,590	24,183
1908 ...	13,009	4,887	174,345	25,048	127	10,643	181,975	6,055	16,384
1909 ...	13,797	6,283	216,286	27,095	122	12,498	201,393	9,140	11,564
1910 ...	13,099	6,329	266,783	29,094	124	14,728	273,614	7,643	9,871
1911 ...	14,584	6,554	329,751	28,921	133	16,430	392,129	22,075	11,015
1912 ...	12,991	6,718	286,614	26,623	143	14,451	134,079	19,978	27,917
1913 ...	16,271	6,678	393,320	44,113	160	16,058	192,565	4,052	28,214

Year.	Quick-silver.	Salt.	Slag and Slag Wool.	Sodium Salts.					
				Bicar-bonate.	Carbon-ate.	Hydrox-ide.	Nitrate. (Chile Saltpeter).	Soda, Calcined.	Sulphate and Sulphite.
1901...	27	286,424	27,269	1,086	1,382	4,926	13,481	45,967	45,462
1902...	109	328,324	22,726	954	2,449	5,650	14,737	33,109	56,748
1903...	62	399,184	14,674	1,016	2,982	5,886	17,583	46,086	47,660
1904...	43	347,351	38,587	1,524	3,050	5,084	21,075	43,590	45,506
1905...	48	284,203	28,032	1,881	4,113	5,925	20,531	46,768	54,377
1906...	21	97,878	49,912	2,120	5,860	6,101	22,099	41,598	64,217
1907...	26	92,288	46,680	1,764	2,680	7,462	22,715	36,802	69,231
1908...	26	318,395	74,821	1,713	3,842	7,626	23,549	56,839	78,510
1909...	29	364,107	61,674	1,292	2,968	8,314	28,019	54,493	74,512
1910...	31	370,074	58,832	1,370	5,994	9,295	27,095	56,545	89,208
1911...	36	374,633	88,423	1,598	1,782	10,635	27,937	60,102	89,110
1912...	37	430,137	128,740	1,584	1,057	12,460	27,431	66,760	85,416
1913...	53	432,387	....	1,869	1,354	13,030	27,507	69,993	83,239

Year.	Sodium and Potassium Salts.		Stassfurt Salts.	Strontium.		Sulphur.	Sulphuric Acid.
	Chromates.	Sulphides.		Carbonate. (*n*)	Salts.		
1901	2,791	2,763	592,347	384	1,022	621	42,853
1902	2,656	4,565	499,220	762	1,546	576	47,666
1903	2,977	5,845	501,385	819	1,389	1,052	50,109
1904	2,272	5,489	631,762	613	1,207	1,418	52,696
1905	2,133	6,569	852,454	613	1,386	1,198	48,701
1906	2,877	6,730	831,293	1,726	1,578	1,582	52,720
1907	3,016	8,103	839,889	1,462	1,671	1,501	49,950
1908	4,402	6,536	818,677	1,494	1,822	1,765	60,588
1909	4,789	7,596	946,457	2,636	1,832	1,935	63,817
1910	4,246	8,679	1,181,208	2,456	1,275	2,727	66,581
1911	5,193	7,837	1,154,974	595	....	1,757	64,888
1912	5,167	7,640	....	1,830	138	1,746	75,962
1913......	5,667	9,226	....	1,958	330	3,472	64,968

Year.	Super-phosphate.	Tin, Crude.	Zinc.				Zinc White, Zinc Gray and Litho-phone.
			Ore.	Spelter and Scrap.	Drawn or Rolled.	Sulphate.	
1900.......	77,118	1,626	34,941	51,899	16,709	382	20,729
1901.......	79,190	1,683	14,002	54,490	16,517	324	24,201
1902.......	77,818	2,271	46,965	70,292	17,015	430	28,400
1903.......	99,672	2,581	40,458	67,057	15,715	264	27,527
1904.......	129,925	2,965	40,488	70,063	17,917	332	26,898
1905.......	115,886	3,259	38,972	67,675	18,982	296	27,877
1906.......	104,713	4,845	42,546	69,142	17,794	426	26,296
1907.......	115,049	4,244	34,863	93,649	21,484	425	30,453
1908.......	125,464	3,707	39,450	75,290	18,661	347	26,372
1909.......	168,988	5,431	51,994	82,225	18,961	342	25,970
1910.......	211,812	7,530	59,440	8,803	26,623	334	36,350
1911.......	221,521	7,582	48,998	81,042	36,093	387	34,419
1912.......	271,349	6,368	51,242	105,328	26,379	....	44,169
1913.......	282,653	6,437	44,731	109,606	24,965	....	46,106

(*a*) From *Statistisches Jahrbuch für das Deutsches Reich.* (*b*) Includes celestite. (*d*) Includes precipitated chalk. (*f*) Includes sodium cyanide. (*g*) Includes tripoli. (*h*) Includes nickel ore. (*i*) Included under chromium ore. (*k*) Included under bauxite. (*l*) Included under magnesium chloride. (*m*) Includes all alkali metals. (*n*) Includes witherite.

GREECE

The statistics of mineral production in Greece, according to the latest available reports, are summarized in the following table:

MINERAL PRODUCTION OF GREECE (*a*)
(In metric tons or dollars; 1 drachma = 20 cents)

Year.	Chrome Ore.	Emery.	Gypsum.	Iron Ore.	Iron Ore, Manganiferous.	Lead, Soft.	Lead Ore, Argentiferous.	Lead, Argentiferous.	Lead, Fume.	Lignite.
1901 ..	4,580	5,691	671	278,640	196,152	(*b*)	(*b*)	17,644	5,292	9,726
1902 ..	11,680	4,727	172	364,340	170,040	(*b*)	430	14,048	1,647	6,500
1903 ..	8,478	5,586	94	531,804	152,740	(*b*)	(*b*)	12,361	(*b*)	8,687
1904 ..	6,530	6,182	117	422,159	108,319	(*b*)	(*b*)	15,186	(*b*)	13,500
1905 ..	8,900	6,972	57	465,622	89,687	(*b*)	(*b*)	13,729	(*b*)	11,757
1906 ..	11,530	7,718	85	680,620	96,382	(*b*)	(*b*)	12,308	(*b*)	11,582
1907 ..	11,730	10,652	105	768,863	92,970	(*b*)	(*b*)	13,814	(*b*)	11,719
1908 ..	4,350	7,471	61	531,368	65,757	(*b*)	(*b*)	15,892	(*b*)	8,786
1909 ..	9,600	8,193	208	475,616	54,926	(*b*)	(*c*)	14,948	(*b*)	3,873
1910 ..	9,450	12,939	243	535,482	50,015	(*c*)	8,355	16,710	(*b*)	1,500
1911 ..	12,915	10,544	1,263	496,731	27,482	......	182,324	14,283	....	....
1912 ..	6,468	3,359	127	376,931	12,212	......	175,463	14,489	....	....
1913 ..	6,342	5,560	2,230	310,078	6,323	......	159,348	18,309	....	170
1914 ..	7,059	16,112	639	299,286	1,315	......	151,581	20,684	....	20,002

Year.	Magnesite.			Manganese Ore.	Puzzolan.	Sea Salt.	Sulphur.	Zinc Ore.	
	Crude.	Bricks.	Calcined.					Blende.	Calamine, Calcined.
1901...	20,348	500	2,009	14,166	80,169	23,079	3,212	454	17,764
1902...	23,020	935	4,730	14,960	32,514	25,200	1,391	(*b*)	18,670
1903...	28,415	(*b*)	(*b*)	9,340	40,978	26,000	1,266	(*b*)	12,350
1904...	9,133	(*b*)	(*b*)	8,549	44,644	27,000	1,225	(*b*)	19,913
1905...	37,063	(*b*)	(*b*)	8,171	41,900	25,201	1,126	(*b*)	22,562
1906...	40,584	(*b*)	(*b*)	10,040	30,622	25,167	(*b*)	(*b*)	26,258
1907...	55,816	(*b*)	(*b*)	11,139	39,637	26,966	(*b*)	(*b*)	30,346
1908...	63,079	(*b*)	(*b*)	10,750	52,312	23,988	(*b*)	28,739	24,101
1909...	56,797	294	16,609	5,374	46,238	29,448	(*b*)	41,656	30,159
1910...	18,073	295	19,982	41	31,609	25,978	(*b*)	(*f*)5,845	28,898
1911...	86,956	275	27,530	(*e*) 733	31,647	26,952	(*h*)31,905	35,856	30,512
1912...	106,338	496	33,848	(*e*)8,082	19,400	31,400	(*h*)31,938	39,585	28,912
1913...	98,517	....	31,815	(*e*) 556	24,906	19,215	(*h*)128,932	30,717	20,646
1914...	136,701	493	28,563	558	28,909	29,717	129,129	32,440	20,308

(*a*) Statistics up to 1903 communicated by E. Grohmann, Seriphos. Statistics for 1903 and subsequent years from *Statistique du Mouvement Minier de Grèce*. The figures represent sales or shipments. (*b*) Not reported. (*c*) No sales, but production of lead ore is reported at 240,013 tons in 1909 and 185,207 tons in 1910. (*e*) Sales. (*f*) Production in 1910 was 37,108 tons. (*h*) Including pyrite.

INDIA

The official statistics of mineral production in British India are summarized in the subjoined table:

MINERAL PRODUCTION OF INDIA (*a*)
(In metric tons or dollars; £1 = $5)

Year.	Amber.	Coal.	Chromite.	Diamonds *Carats.*	Gold. (*c*)	Graphite.	Iron Ore.	Jade. (*e*) *Cwt.*	Magnesite.
1901...	$55	6,742,214	.....	....	$9,394,723	2,530	(*d*)58,725	206	(*b*)
1902...	2,160	7,543,625	.....	....	9,611,985	4,648	(*d*)77,273	174	3,597
1903...	2,070	7,557,754	289	....	11,203,926	3,448	(*d*)62,337	99	838
1904...	4,190	8,348,561	3,654	286.5	11,513,340	2,955	72,832	130	1,193
1905...	4,725	8,552,422	2,751	172.4	11,760,957	2,361	104,984	106	2,645
1906...	3,545	9,940,247	4,445	305.9	10,852,546	2,642	92,933	116	1,861
1907...	1,925	11,325,696	18,596	628.0	10,348,795	2,472	69,829	2,636	189
1908...	1,820	12,974,558	4,821	140.8	10,597,404	2,919	73,457	3,211	7,655
1909...	1,435	12,060,550	9,398	147.3	10,728,900	3,182	84,774	2,487	749
1910...	1,415	12,249,744	1,765	77.7	10,717,300	4,319	55,461	1,908	5,265
1911...	665	12,919,587	3,865	53.0	10,890,804	4,047	372,049	2,063	3,546
1912....	895	14,942,340	2,936	27.8	11,054,608	*Nil*	589,508	806	15,626
1913...	145	16,467,337	5,767	115.7	11,152,408	*Nil*	376,779	3,281	16,457
1914...	1,370	16,727,691	5,982	54.7	11,378.435	*Nil*	448,741	9,925	1,707

Year.	Manganese Ore.	Mica.	Petroleum. *Gallons.*	Rubies. *Carats.*	Salt.	Saltpeter (Potassium Nitrate.)	Tin and Tin Ore.
1901.....	122,831	1,157	50,075,117	229,127	1,119,672	17,711	71
1902.....	160,311	1,139	56,607,688	169,965	1,056,899	17,320	101
1903.....	174,563	870	87,859,069	227,213	836,394	18,711	112
1904.....	152,601	1,126	118,491,382	265,901	1,122,731	14,200	71
1905.....	250,788	1,302	144,798,444	266,584	1,212,504	15,745	77
1906.....	579,231	2,669	140,553,122	329,692	1,176,269	16,822	97
1907.....	916,770	2,652	152,045,677	604,217	1,120,427	18,664	80
1908.....	685,135	2,720	176,646,320	356,044	1,300,416	19,620	96
1909.....	654,974	1,671	233,678,087	265,010	1,207,082	20,953	85
1910.....	813,721	1,153	214,928,647	262,019	1,509,398	16,140	167
1911.....	681,015	1,722	225,792,094	288,213	1,245,118	14,679	189
1912.....	643,209	2,227	249,083,518	323,245	1,331,991	14,797	382
1913.....	828,088	2,324	277,555,225	278,706	1,320,069	14,461	359
1914.....	693,824	2,057	259,342,710	304,872	1,223,022	15,489	374

(*a*) Records of the Geological Survey of India. (*b*) Not reported. (*c*) L1 = ?4.866. (*d*) Production of iron ore in Bengal only. (*e*) Exports in cwt. of 112 lb.

ITALY

The following tables itemize the statistics of the production and the foreign commerce of mineral and metallurgical products in Italy:

MINERAL PRODUCTION AND REFINED PRODUCTS OF ITALY (*a*)
(In metric tons or dollars; 5 lire = $1)

Year.	Alum.	Aluminium Sulphate.	Alunite.	Antimony.	Antimony Ore.	Asphalt, Mastic, and Bitumen.	Asphaltic Rock.	Barytes.
1900....	1,097	2,403	5,200	1,174	7,609	33,127	101,738	14,003
1901.....	1,075	2,260	4,900	1,721	8,818	31,814	104,111	13,245
1902.....	3,995	2,620	8,200	1,574	6,116	33,684	64,245	13,245
1903.....	3,980	2,210	8,100	905	6,927	35,757	89,078	12,420
1904.....	2,490	2,210	8,000	836	5,712	30,817	111,390	12,290
1905.....	2,975	2,740	8,500	327	5,083	26,838	106,586	12,670
1906.....	2,878	2,800	7,500	537	5,704	34,386	130,225	12,020
1907.....	3,175	3,010	7,600	610	7,892	38,568	161,126	15,732
1908.....	2,875	2,100	6,165	345	2,821	34,761	134,163	15,432
1909.....	2,580	2,750	5,636	59	1,077	39,165	111,067	16,240
1910.....	2,510	2,773	6,081	*Nil*	2,194	41,705	162,212	14,420
1911.....	2,725	2,493	6,100	*Nil*	2,441	50,179	188,133	13,620
1912.....	1,299	2,727	6,002	*Nil*	1,878	52,707	181,397	13,420
1913.....	1,009	3,308	5,976	76	1,822	56,750	171,097	12,970
1914.....	1,307	3,229	3,700	138	555	33,752	119,853	12,970

Year.	Borax, Refined.	Boric Acid.		Coal. (*c*)	Coal (Briquettes).	Coke.	Copper.		
		Crude.	Refined.				Ore.	Ingot, etc.	Sulphate.
1900...	858	2,491	283	479,896	703,740	487,831	95,644	10,405	13,191
1901...	544	2,558	347	425,614	754,800	490,803	107,750	2,639	15,374
1902...	375	2,763	238	414,569	713,430	528,765	101,142	10,230	14,601
1903...	377	2,583	187	346,887	724,993	554,559	114,823	11,217	18,164
1904...	569	2,624	314	362,151	903,610	607,297	157,503	11,873	17,237
1905...	1,007	2,700	749	412,916	842,250	627,984	149,035	16,132	26,212
1906...	1,062	2,561	562	473,293	829,277	672,689	147,137	15,456	34,270
1907...	880	2,305	466	453,137	787,087	717,704	167,619	17,491	45,263
1908...	1,024	2,520	429	480,029	822,699	813,842	106,629	18,280	42,598
1909...	1,110	2,431	578	555,073	924,479	999,381	90,272	20,005	28,551
1910...	912	2,502	695	562,154	918,055	1,160,543	68,369	22,467	36,236
1911...	738	2,648	444	555,137	794,206	363,493	68,136	22,908	44,626
1912...	813	2,309	760	663,812	876,565	437,706	86,001	26,659	52,311
1913...	1,070	2,410	743	701,081	896,091	1,336,382	89,487	24,625	44,497
1914...	1,164	2,537	838	781,338	968,600	1,276,318	88,953	1,839	31,302

Year.	Gold.		Graphite.	Iron and Steel.				
	Ore.	Bullion.		Ore.	Pig.	Bar, Sheet, Pipe, Wire, etc.	Tin Plate.	Steel.
1900.....	5,840	$52,357	9,720	247,278	23,990	190,518	10,000	115,887
1901.....	890	8,120	10,313	232,299	15,819	180,729	7,550	123,310
1902.....	1,215	10,269	9,210	240,705	30,640	163,055	8,800	108,864
1903.....	5,734	24,667	7,920	374,790	90,744	177,392	11,275	154,134
1904.....	6,746	36,996	9,765	409,460	112,598	181,385	16,655	177,086
1905.....	1,200	7,200	10,572	366,616	181,248	205,915	18,560	244,793
1906.....	6,543	42,720	10,805	384,217	180,940	236,946	16,350	332,924
1907.....	13,475	41,000	10,989	517,952	148,996	248,157	24,423	346,749
1908.....	14,671	48,223	12,914	539,120	158,100	302,509	28,277	437,674
1909.....	2,890	18,230	11,583	505,095	254,904	281,098	35,880	608,795
1910.....	2,147	11,746	12,510	551,259	399,700	311,210	42,670	670,983
1911.....	2,080	16,440	12,621	373,786	302,931	303,223	25,662	697,958
1912.....	2,366	13,271	13,170	582,066	379,989	179,516	28,916	801,907
1913.....	2,047	23,580	11,145	603,116	426,755	591,763	29,185	846,085
1914.....	205	(*b*)	8,567	706,246	385,340	705,273	26,284	796,152

Year.	Lead. Ore.	Lead. Pig.	Manganese Ore.	Manganiferous Iron Ore.	Marble.	Petroleum. Crude.	Refined Petroleum, Benzene, etc.	Pumice Stone.
1900	35,103	23,763	6,014	26,800	310,336	1,683	6,077	7,000
1901	43,449	25,796	2,181	24,290	334,146	2,246	4,211	8,300
1902	42,330	26,494	2,477	23,113	363,463	2,633	5,413	8,300
1903	42,443	22,126	1,930	4,735	374,975	2,486	4,577	8,300
1904	42,846	23,475	2,836	2,836	390,118	3,543	6,388	11,600
1905	39,030	19,077	5,384	5,384	389,869	6,122	9,924	11,300
1906	40,945	21,268	3,060	20,500	430,202	7,452	10,954	16,366
1907	(*d*)43,037	22,978	3,654	18,874	434,612	8,326	10,556	11,500
1908	46,649	26,003	2,750	17,812	425,600	7,088	10,876	15,000
1909	37,945	22,133	4,700	25,830	391,295	5,895	11,077	10,000
1910	36,840	14,495	4,200	25,700	427,274	7,069	12,149	12,900
1911	39,008	16,684	3,515	6,482	497,741	10,390	15,569	16,430
1912	41,680	21,450	2,641	*Nil*	522,088	7,479	13,792	17,386
1913	44,654	21,674	1,622	*Nil*	509,342	6,572	11,160	14,793
1914	45,538	20,464	1,649	*Nil*	431,087	5,542	11,873	14,376

Year.	Pyrite (Cupriferous in Part).	Quicksilver. Ore.	Quicksilver. Metal.	Salt. Brine.	Salt. Rock.	Salt. Sea.	Silver. Ore.	Silver. Bullion. *Kg.*
1900	71,616	33,930	260	10,890	18,331	338,034	584	31,169
1901	89,376	38,614	278	10,690	23,054	401,443	511	32,464
1902	93,177	44,261	259	10,581	23,677	424,239	421	29,522
1903	101,455	55,528	312	10,962	25,911	451,633	405	24,388
1904	112,004	60,403	352	11,878	18,638	433,810	143	24,943
1905	117,667	63,378	369	12,756	19,669	405,274	170	20,215
1906	122,364	80,638	417	13,751	19,007	496,872	48	20,362
1907	126,925	76,561	434	19,238	31,540	454,454	62	20,502
1908	131,721	82,534	684	15,180	24,033	473,857	53	20,746
1909	149,084	97,592	771	15,081	28,026	421,362	44	20,534
1910	165,688	87,129	894	16,600	39,197	447,440	32	14,237
1911	165,273	97,803	955	17,251	43,763	460,439	24	12,143
1912	277,585	88,200	1,000	18,775	39,954	466,220	27	14,363
1913	317,334	109,379	1,004	17,727	41,323	585,028	*Nil*	13,094
1914	335,531	119,223	1,073	18,396	41,715	512,992	*Nil*	15,254

Year.	Sulphur. Crude (Fused).	Sulphur. Ground.	Sulphur. Refined.	Talc, Ground.	Zinc. Ore.	Zinc. Spelter.
1900	544,119	167,466	157,957	14,415	139,679	547
1901	563,096	171,252	141,431	11,770	135,784	511
1902	539,433	125,620	127,483	10,100	131,965	....
1903	553,751	139,376	139,464	6,300	157,521	126
1904	527,563	189,266	163,695	6,740	148,365	189
1905	568,927	180,676	180,774	6,626	147,834	5
1906	499,814	176,476	170,990	7,894	155,751	69
1907	426,972	151,338	160,617	8,850	160,517	188
1908	445,312	160,693	156,995	9,410	(*e*)152,254	(*b*)
1909	435,060	132,531	144,579	9,530	(*g*)130,890	(*b*)
1910	(*i*)430,366	171,570	169,093	11,580	(*g*)146,307	(*b*)
1911	414,161	158,977	166,802	14,156	139,719	(*b*)
1912	389,451	164,864	168,514	14,324	149,776	(*b*)
1913	386,310	156,103	151,713	21,350	158,278	(*b*)
1914	377,843	165,362	149,100	22,478	145,914	(*b*)

(*a*) From *Rivista del Servizio Minerario.* (*b*) Not reported. (*c*) Includes anthracite, lignite, fossil wood, and bituminous schist. (*d*) Does not include 680 tons lead and zinc ore. (*e*) Includes 560 tons lead-zinc ore. (*g*) Includes 290 and 300 tons lead-zinc ore, 1909 and 1910. (*i*) Besides 21,297 tons ore sold. Natural.

MINERAL IMPORTS OF ITALY (*a*)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Arsenic. *Kg.*	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.
1901.....	49	1,800	2,019	1,450	825	232	14,872	20,731
1902.....	80	1,200	1,536	1,020	1,170	516	13,732	15,216
1903.....	98	4,400	1,691	1,567	1,099	504	15,547	10,063
1904.....	131	3,700	2,174	2,604	1,875	271	15,260	6,891
1905.....	117	3,400	1,806	3,252	1,444	112	15,797	5,556
1906.....	50	5,300	2,171	2,854	1,400	163	18,937	7,714
1907.....	163	3,100	3,110	3,661	1,540	307	29,024	6,156
1908.....	153	2,800	2,548	3,730	1,523	333	28,935	7,210
1909.....	293	4,800	2,285	3,826	2,094	386	25,250	11,120
1910.....	342	5,300	2,051	3,365	1,777	363	22,183	9,007
1911.....	358	5,500	3,892	4,238	2,024	741	24,467	7,942
1912.....	636	4,600	4,080	3,548	1,986	380	23,423	6,809
1913.....	513	2,500	4,750	4,300	1,771	159	19,950	5,501
1914.....	198	3,500	2,710	2,924	1,409	280	15,002	3,810
1915.....	825	1,700	5,380	4,139	1,319	719	5,969	2,052

Year.	Coal.	Copper, Ore.	Copper, Cement.	Copper, Brass and Bronze.	Copper and Iron Sulphates.	Gold. *Kg.*	Graphite.
1900......	4,947,180	5,290	1,298	9,249	32,127	309	982
1901......	4,838,994	11,047	1,987	8,659	32,058	494	102
1902......	5,406,069	9,422	2,299	10,865	25,107	479	60
1903......	5,546,823	9,459	649	9,588	24,566	1,396	63
1904......	5,904,578	8,104	309	15,198	37,298	1,961	52
1905......	6,437,539	6,879	486	18,188	30,684	5,768	107
1906......	7,673,435	9,363	802	21,458	25,060	4,571	361
1907......	8,300,439	18,023	888	28,937	15,939	4,443	267
1908......	8,452,320	14,784	344	28,025	25,037	(*d*) 8,367	383
1909......	9,303,506	11,303	630	22,391	9,137	(*d*) 8,311	141
1910......	9,338,752	7,550	456	30,339	13,599	(*d*)13,188	229
1911......	9,595,882	6,607	277	38,650	37,929	(*d*)12,712	246
1912......	10,057,228	6,253	578	43,729	36,602	(*d*)10,545	403
1913......	10,834,008	737	352	39,552	30,472	(*d*) 9,940	567
1914......	9,758,877	850	*Nil*	28,422	21,939	(*d*)10,281	162
1915......	8,376,977	571	....	54,718	14,081	(*d*) 6,389	1,506

Year.	Iron.		Iron and Steel Scrap.	Lead.		Lead Oxide and Carbonate.	Mineral Paints.
	Ore.	Pig.		Ore. (*c*)	Metal and Alloys in Pigs.		
1900......	19,205	160,686	197,415	9,134	3,248	557	958
1901......	4,054	159,972	148,305	9,063	2,926	815	865
1902......	4,314	155,143	198,914	1,680	7,563	846	670
1903......	5,937	126,756	206,036	689	5,398	768	859
1904......	4,390	149,130	246,359	2,187	4,541	871	940
1905......	4,745	136,077	276,311	465	6,764	686	974
1906......	6,452	168,985	344,977	4,526	10,958	984	964
1907......	22,046	231,042	362,567	4,342	9,231	953	1,119
1908......	31,090	254,239	326,119	5,620	11,742	1,474	2,616
1909......	28,150	246,730	416,354	3,003	10,011	1,132	1,713
1910......	17,673	204,854	386,604	1,426	14,674	1,225	1,775
1911......	50,554	234,770	392,703	6,042	20,187	1,077	1,756
1912......	18,606	267,355	343,728	12,391	15,627	917	1,962
1913	8,026	221,688	326,231	9,552	11,494	682	2,410
1914......	4,592	219,995	254,858	15,736	9,820	533	2,053
1915......	7,607	....	....	6,181	17,326	183	1,811

Year.	Nickel Alloys and Manufactures.	Petroleum.	Phosphate Rock.	Potash, Ammonia, and Caustic Soda.	Potassium Sulphate.	Quicksilver.	Silver. *Kg.*	Slag, Metalliferous.
1901.....	476	69,298	142,108	14,693	1,411	36	4,391	7,312
1902.....	561	68,781	159,341	17,617	1,566	57	8,768	5,634
1903.....	525	68,220	172,328	17,528	1,353	28	12,541	8,849
1904.....	652	69,233	217,162	14,846	1,663	25	15,885	3,821
1905.....	574	66,493	240,144	17,752	1,804	57	20,697	72,785
1906.....	717	64,541	307,762	16,718	1,534	12	20,410	88,118
1907.....	725	72,715	384,896	15,225	3,866	11	21,829	5,378
1908.....	1,079	82,373	531,921	14,962	4,891	10	(*d*)83,434	1,122
1909.....	540	88,929	478,199	15,547	5,333	2.2	(*d*)47,234	878
1910.....	1,311	84,748	422,714	16,983	7,753	2.5	(*d*)55,516	3,153
1911.....	1,584	119,245	479,042	16,312	9,493	2.0	(*d*)52,576	95
1912.....	1,742	113,231	466,144	17,816	13,466	1.5	(*d*)79,763	164
1913.....	1,200	115,374	529,776	17,407	9,454	0.3	(*d*)87,856	2,560
1914.....	1,112	116,276	513,998	16,382	3,708	*Nil*	102,090(*d*)	700
1915.....	1,812	111,426	456,901	21,877	900	43	(*d*)83,018	1,780

Year.	Sodium Salts.		Sod. and Pot. Nitrates, Refined.	Tin.		Zinc.			
	Carbonate.	Nitrate (Crude).		Block.	Mnfrs.	Ore.	Oxide.	Spelter and Old.	Mnfrs.
1900....	23,215	27,706	511	1,643	56	85	1,034	3,627	3,543
1901....	21,956	40,498	315	1,858	91	23	813	3,991	4,079
1902....	26,133	24 483	314	2,114	110	131	904	3,805	4,167
1903....	24,753	43,480	638	2,288	130	46	1,416	4,551	4,461
1904....	27,747	32,283	613	2,170	150	362	1,124	5,202	4,168
1905....	29,066	46,517	689	2,304	103	14	1,246	5,997	4,701
1906....	31,170	32,508	395	3,361	167	2,042	1,920	6,835	4,421
1907....	35,538	41,457	668	2,771	183	11	1,962	8,152	5,407
1908....	38,268	60,784	428	2,602	187	7	2,026	9,339	5,112
1909....	38,252	43,658	532	2,555	191	13	1,571	9,222	4,572
1910....	45,174	61,192	1,083	2,760	238	18	2,001	8,971	5,416
1911....	45,596	59,561	417	2,524	211	428	2,100	10,742	5,892
1912....	49,284	54,634	529	2,627	157	*Nil*	2,550	11,955	5,833
1913....	52,332	67,418	574	2,973	144	5	2,983	12,448	6,071
1914....	48,115	59,850	310	2,744	110	*Nil*	2,348	10,518	4,002
1915....	53,191	71,730	2	4,493	28	....	1,833	12,843	1,087

MINERAL EXPORTS OF ITALY (*a*)

(In metric tons or dollars; 5 lire = $1)

Year.	Antimony.	Asbestos.	Asphaltum.	Barytes.	Borax and Boric Acid.	Cement and Hydraulic Lime.	Lime.	Coal.
1901.....	765	302	21,856	32	2,190	8,463	4,215	25,594
1902.....	359	144	20,884	91	1,847	7,930	3,802	33,374
1903.....	314	222	24,303	35	901	6,325	4,089	29,219
1904.....	107	163	14,880	70	1,122	7,810	5,007	35,149
1905.....	132	236	23,740	162	2,255	8,445	4,194	38,555
1906.....	208	205	27,176	147	2,777	6,774	3,118	31,666
1907.....	115	142	26,036	152	1,330	4,477	3,224	40,769
1908.....	10	193	24,158	724	1,005	5,439	2,533	46,774
1909.....	8	527	21,978	125	1,704	7,534	3,525	51,343
1910.....	2	485	26,125	150	1,536	7,131	5,764	48,144
1911.....	*Nil*	517	28,455	353	1,347	10,742	9,440	40,800
1912.....	11	571	13,158	381	1,661	55,091	6,736	26,298
1913.....	*Nil*	672	6,645	234	1,373	55,908	5,161	192,002
1914	51	509	6,367	210	1,195	40,880	5,161	52,620
1915.....	3	148	6,720	3,288	1,702	40,430	627	78,987

Year.	Copper, Ore.	Copper and Iron Sulphate.	Gold. *Kg.*	Graphite.	Iron.		
					Ore.	Pig.	Scrap.
1900...........	1,179	60	2,763	7,820	170,286	329	....
1901...........	9	20	2,955	7,169	121,592	311	....
1902...........	11	39	733	7,098	209,070	395	....
1903...........	15	44	1,291	7,068	98,319	810	....
1904...........	43	29	1,494	7,433	2,577	229	....
1905...........	77	249	1,731	6,811	11,358	1,395	....
1906...........	189	102	1,476	4,904	1,833	254	....
1907...........	179	835	802	7,474	26,000	121	....
1908...........	188	721	7,588	7,009	35,653	176	1,676
1909...........	233	1,211	15,452	8,125	46	209	1,480
1910...........	969	741	16,643	7,647	9,892	327	2,450
1911...........	130	157	14,144	7,633	22,851	290	3,390
1912...........	267	1,445	13,993	7,785	12,313	51	5,662
1913...........	285	609	16,440	8,329	9,660	555	6,895
1914...........	78	1,856	6,724	7,589	8,944	69	4,636
1915...........	2	62	1,072	6,508	157	....	....

Year.	Lead.			Mineral Paints.	Phosphate Rock.	Quicksilver.	Salt.	Silver *Kg.*
	Ore.	Lead Alloys, in Pigs.	Oxide and Carbonate.					
1900.....	3,741	5,018	367	2,977	1,726	259	112,900	25,310
1901.....	3,977	4,463	410	2,913	1,290	301	114,210	42,325
1902.....	3,354	5,650	404	2,953	894	215	145,190	20,427
1903.....	5,041	2,911	426	3,305	2,942	222	144,910	9,486
1904.....	5,524	1,954	347	3,231	2,812	266	130,940	24,165
1905.....	4,311	976	310	3,632	3,519	243	116,040	25,947
1906.....	8,356	2,005	315	4,502	1,652	278	126,199	18,262
1907.....	3,213	1,548	240	4,602	4,560	350	99,191	18,164
1908.....	2,041	1,243	219	3,446	2,271	565	85,489	(*d*)28,716
1909.....	1,037	782	211	4,310	2,979	714	103,895	(*d*)87,653
1910.....	4,122	933	197	3,945	3,627	781	122,404	(*d*)22,403
1911.....	15,791	637	196	4,182	5,427	1,037	119,173	(*d*)28,434
1912....	17,062	4,122	75	4,417	1,285	993	155,543	(*d*)28,275
1913....	16,950	577	314	4,166	4,171	993	161,118	179,322
1914.....	15,403	189	687	4,220	8,569	760	124,860	14,451
1915.....	3,817	14	339	3,458	1,809	853	10,899	27,890

Year.	Slag.	Sodium Salts.			Sulphur.	Tin.		Zinc.		
		Carbonate	Nitrate (Crude).	Sod. and Pot. Nitrates, Refined.		Block.	Manufactures	Ore.	Oxide.	Spelter and rap.
1900....	4,222	486	58	129	479,139	147	153	111,870	102	359
1901....	3,261	377	116	59	414,018	202	187	103,020	140	349
1902....	3,615	446	346	259	439,242	236	174	114,894	122	338
1903....	4,929	482	781	492	461,289	173	180	116,449	116	591
1904....	4,458	376	363	230	437,067	171	151	126,393	483	263
1905....	9,844	214	424	159	381,128	285	107	117,810	173	434
1906....	8,990	253	80	133	336,339	303	81	144,244	687	639
1907....	10,934	200	138	102	297,378	434	117	142,271	727	1,182
1908....	12,122	583	37	57	330,093	180	173	122,456	395	984
1909....	17,163	517	464	163	329,233	85	126	123,936	212	983
1910....	10,488	321	98	45	344,513	164	245	127,315	957	845
1911....	8,274	180	168	15	398,592	166	319	133,471	1,577	616
1912...	19,563	243	27	7	376,387	83	359	152,840	2,165	1,222
1913....	8,251	337	50	10	351,339	152	394	144,644	1,313	1,566
1914....	7,822	123	179	12	267,594	179	313	89,776	1,219	1,234
1915....	715	94	....	5	286,233	36	364	59,734	2,560	86

(*a*) From *Statistica del Commercio speciale di Importazione e di Esportazione.* (*b*) Not reported. (*c*) Includes argentiferous lead ore. (*d*) Includes coin, bullion, sheets, and leaf.

JAPAN

The total mineral production of the Japanese Empire, according to the latest available returns, is shown in the following table, in metric tons, unless otherwise specified. Figures in full-faced type are either provisional figures or estimates.

MINERAL PRODUCTION OF JAPAN (*a*)

Year.	Antimony.		Arsenic. *Kg.*	Coal.	Copper.	Gold. *Kg.*	Graphite	Pig. Iron.	Lead.
	Ore.	Metal.							
1900....	81	349	4,669	7,370,667	24,317	2,124	94	24,841	1,878
1901....	118	429	10,312	8,884,812	27,392	2,475	88	29,449	1,803
1902....	88	528	12,188	9,588,910	29,034	2,975	97	32,130	1,644
1903....	153	434	6,000	10,088,845	33,245	3,140	114	33,870	1,728
1904....	104	321	4,000	10,723,796	33,187	2,765	216	38,143	1,803
1905....	96	190	8,333	11,955,946	35,944	3,048	209	53,210	2,272
1906....	97	627	5,250	13,468,529	36,963	2,873	177	57,373	4,305
1907....	(*b*)	248	7,491	13,764,731	40,183	2,938	103	44,447	3,079
1908....	(*b*)	198	19,838	14,767,638	41,399	3,598	177	42,007	2,910
1909(*d*)	10	157	8,061	14,810,412	45,117	3,932	121	46,627	3,337
1910(*d*) .	8	120	11,463	15,433,621	48,545	4,368	145	58,043	3,845
1911....	....	97	5,760	17,632,710	53,401	4,690	114	63,986	4,125
1912....	....	80	....	19,515,285	62,939	5,233	149	56,265	3,764
1913...	....	(*d*)21	....	21,664,764	66,537	4,666	(*d*)665	57,513	3,779
1914....	....	....	....	**21,315,962**	**69,816**	**7,217**	....	....	....
1915....	....	....	....	**19,000,000**	**75,000**	**8,900**	....	....	....

Year.	Manganese Ore.	Petroleum. *Gallons.*	Phosphates.	Pyrite.	Quicksilver. *Kg.*	Salt. *Hectoliters.*	Silver. *Kg.*	Sulphur.	Tin.
1900....	15,831	18,844,034	(*b*)	16,166	270	11,890,361	58,799	14,439	12.3
1901....	16,270	30,470,068	(*b*)	17,589	750	12,463,771	54,739	16,548	14.1
1902....	10,844	39,056,820	196	18,580	1,418	11,042,192	57,635	18,287	18.6
1903....	5,616	34,850,129	191	16,149	206	6,574,890	58,704	22,914	19.0
1904....	4,324	50,724,174	13	24,886	*Nil.*	7,019,650	61,339	25,587	25.0
1905....	14,017	51,573,754	1,519	25,569	349	(*b*)	82,886	24,652	26.0
1906....	54,339	47,132,800	3,037	36,038	336	(*b*)	76,247	27,589	77.0
1907....	20,586	60,005,957	1,721	56,166	456	(*f*)636,168	95,600	33,329	31.8
1908(*d*) .	11,130	60,110,558	740	33,867	804	(*f*)659,202	123,180	33,149	25.7
1909(*d*) .	8,708	65,165,860	3,781	27,066	335	(*f*)696,049	127,917	36,317	22.8
1910....	11,120	65,789,858	1,042	78,418	407	(*f*)696,474	141,613	43,155	23.
1911....	9,787	63,843,601	2,271	73,879	1,021	(*g*)567,715	138,287	50,274	24.8
1912....	12,060	72,839,260	7,847	74,929	27	....	152,385	55,005	35.6
1913....	(*d*)12,070	67,557,322	19,047	114,589	....	....	146,180	59,481	379.0
1914....	....	**84,869,794**	....	....	....	....	**151,477**	**74,115**	.....
1915....	....	**115,011,876**	....	....	....	....	**155,000**	**70,000**	.....

(*a*) From *Résumé Statistique de l'Empire du Japon*, Tokio. (*b*) Not reported. (*d*) From reports of the Japanese Department of Agriculture and Commerce. (*f*) Metric tons including Taiwan, fiscal years. (*g*) Metric tons; from *Résumé Statistique de l'Empire du Japan.*

MEXICO

Owing to the incompleteness of the Mexican statistics of production, we are unable to give any satisfactory table. Exports may, however, be taken as indicating the condition of the mining industry. We owe the statistics for 1908, 1909, and 1910, together with a complete revision of this table, to the courtesy of Don Miguel M. Irigoyen, chief of the Section of Statistics, Secretaria de Hacienda y Credito Publico.

MINERAL EXPORTS OF MEXICO (*a*)
(In metric tons or Mexican dollars)

Year.	Antimony.		Coal.	Copper.		Gold.				
	Metal.	Ore.		Ore.	Ingot.	Ore.	Bullion.	Specie.	Cyanide.	Sulphide.
1898...	......	5,932	118,553	13,146	10,362	$1,037,202	$6,493,735	$367,704	$294,730	$64,061
1899...	......	10,382	113,192	223	25,293	335,849	7,017,286	183,474	115,961	266,782
1900...	......	2,313	38,676	408	27,970	306,392	7,435,864	192,456	128,675	177,193
1901...	......	5,103	17,281	5,576	33,818	284,722	8,324,681	210,431	178,803	81,744
1902...	1,218	1,280	3,406	6,101	63,609	303,979	9,079,371	129,899	78,295	40,658
1903 (*c*)	2,304	7,302	1,840	10,912	51,716	264,503	9,693,692	54,636	85,465	124,020
1904...	1,694	81	125	48,365	57,338	537,290	10,867,272	172,532	79,129	176,090
1905...	1,978	57	497	92,540	56,634	1,513,344	29,636,117	106,470	397,814	138,033
1906...	2,418	178	91	73,193	46,767	5,369,173	21,072,014	37,746	337,294	180,348
1907...	4,615	681	1,532	115,245	51,519	3,033,090	19,653,362	5,023,404	417,162	497,893
1908...	4,046	36	719	70,900	26,214	2,746,289	30,101,546	42,389	144,959	334,944
1909...	4,115	31	235	136,031	32,580	2,346,279	40,725,976	23,678	85,110	250,741
1910...	3,730	6	120	129,568	54,061	2,526,444	46,189,613	37,723	46,803	168,162
1911...	4,131	121	101	109,627	60;493	1,945,660	48,113,427	8,153,293	38,031	141,640
1912...	3,491	15	50,777	103,129	60,439	1,121,333	42,686,667	1,479,292	43,481	119,357
1913...	2,340	(*b*)	40	19,500	29,438	785,531	32,918,172	470,758	54,417	172,188

Year.	Graphite.	Gypsum.	Lead.		Silver.					
			Ore.	Base Bullion.	Ore.	Bullion.	Specie.	Sulphide.	Cyanide.	Slag.
1898...	1,365	1,650	(*b*)	60,918	$11,048,358	$37,137,599	$16,588,789	$1,663,501	$257,342	$46,488
1899...	2,305	1,050	1	67,441	10,766,099	37,585,911	5,580,834	1,929,085	76,942	4,819
1900...	2,561	1,600	468	74,944	12,495,524	41,468,745	22,679,655	1,893,646	67,607	87,880
1901...	762	800	(*b*)	79,097	9,615,939	36,348,374	12,038,158	2,141,685	259,282	93,543
1902...	1,434	(*b*)	118	107,366	4,108,088	45,796,576	17,753,526	1,978,919	108,344	132,093
1903 (*c*)	1,404	(*b*)	11	100,532	11,781,048	48,276,797	16,167,673	1,642,627	135,561	289,900
1904...	970	(*b*)	1	95,010	11,000,869	45,430,020	7,251,132	1,392,356	171,452	202,594
1905...	970	27	1	101,196	8,505,834	63,564,789	20,335,297	736,228	438,094	29,012
1906...	3,915	(*b*)	(*b*)	73,699	9,619,763	63,057,152	42,390,357	595,112	434,885	(*b*)
1907...	3,202	(*b*)	11	76,158	11,396,844	68,187,169	23,848,571	785,116	483,638	(*b*)
1908...	1,076	(*b*)	26	127,010	11,230,372	63,298,659	60,405	791,698	68,849	(*b*)
1909...	1,704	(*b*)	1	118,186	8,057,189	66,789,716	91,006	557,520	78,688	(*b*)
1910...	2,332	1	355	120,662	6,793,896	70,272,894	72,891	208,300	52,053	(*b*)
1911...	2,974	(*b*)	397	124,605	6,766,644	78,515,378	8,901	235,410	159,170	*Nil*
1912...	2,865	(*b*)	59	109,717	5,769,575	82,047,500	8,645	(*d*)	347,277	*Nil*
1913...	1,057	(*b*)	1,386	55,530	2,108,805	63,232,843	2,585,701	423,625	418,522	(*b*)

(*a*) From the *Estadistica Fiscal*. The figures for the calendar years were arrived at by combining those of the successive semesters of the different fiscal years. (*b*) Not reported. (*c*) Figures for 1904 are from *Anuario Estadistico de la República Mexicana* for 1904. (*d*) 11 metric tons.

NORWAY

The official statistics of mineral production, imports and exports are summarized in the following tables:

MINERAL PRODUCTION OF NORWAY (*a*)
(In metric tons or dollars; 1 Krone = 27 cents)

Year.	Apatite. (*b*)	Chrome Ore.	Copper.		Feldspar.	Gold.	Iron.		
			Ore.	Ingot.			Ore.	Pig and Cast.	Bars and Steel.
1902 ...	2,295	22	40,499	1,347	19,591	$36,990	53,675	527	461
1903 ...	1,795	*Nil.*	35,417	1,382	18,590	8,370	53,475	509	442
1904 ...	1,456	154	36,891	1,342	20,835	*Nil.*	45,328	350	395
1905. ..	2,522	*Nil.*	37,045	1,153	22,508	*Nil.*	46,582	474	253
1906 ...	3,482	*Nil.*	32,203	1,333	23,896	5,400	109,259	257	317
1907. ..	1,830	107	39,887	1,517	32,970	*Nil.*	140,804	*Nil.*	283
1908 ...	1,771	*Nil.*	33,688	1,806	34,437	*Nil.*	119,656	....	....
1909 ...	1,364	*Nil.*	42,612	1,594	36,439	8,000	40,389	....	....
1910 ...	703	....	46,308	1,814	39,507	5,000	102,447	....	....
1911 ...	897	....	34,705	1,650	34,864	....	220,524	316	....
1912 ...	1,168	115	60,018	2,130	39,844	....	116,392	291,700	309
1913 ...	757	....	70,349	2,741	40,842	2,200	78,936	465,750	346
1914 ...	750	81	57,951	2,860	19,911	....	652,273	6,909	....

Year.	Molybdenite.	Nickel.		Pyrite, Iron, and Copper.	Rutile.	Silver.		Zinc Ore. (*c*)
		Ore.	Metal.			Ore and Native Silver.	Metal. *Kg.*	
1902.....	20	4,040	40	121,247	*Nil.*	471	6,220	30
1903.....	31	5,670	60	129,939	25	481	7,269	335
1904.....	30	5,352	75	133,603	25	1,297	8,064	42
1905.....	46	5,477	73	162,012	35	1,570	7,100	4,241
1906.....	1,026	6,081	77	197,886	55	1,565	6,370	3,308
1907.....	30	5,781	81	236,038	55	1,756	6,700	400
1908.....	35	5,190	81	269,129	83	2,262	7,470	2,435
1909.....	30	5,770	62	282,606	....	2,729	7,780	983
1910.....	....	19,639	69.8	329,642	116	....	....	2,219
1911.....	....	27,743	172	369,055	76	2,892	7,635	2,240
1912.....	21	30,697	390	464,326	100	4,027	8,400	40
1913.....	12	49,990	690	441,291	77	5,411	9,400	897
1914.....	(*d*)83	48,529	794	414,886	30	7,372	12,904	243

(*a*) *Tabeller vedkommende Norges Bergværkdsdrift*, and *Statistisk Aarbok for Kongeriket Norge.* (*b*) Exports which represent production. (*c*) Includes lead ore. (*d*) Includes wolframite.

MINERAL IMPORTS OF NORWAY (*a*)
(In metric tons)

Year.	Borax. *Kg.*	Cement and Hydraulic Lime.	Coke, Coal, and Cinders. *Hectoliters.*	Copper and Brass.		Iron and Steel.	
				Plates and Bars.	Wares.	Pig.	Bars, Hoops, etc. Wrought Iron.
1902	(*c*)	18,984	19,338,615	1,118	(*c*)	18,969	26,685
1903	(*c*)	17,906	20,086,974	899	309	20,652	21,977
1904	54,953	12,845	21,049,128	688	866	18,891	24,094
1905	(*c*)	13,797	20,973,608	882	1,146	20,828	27,740
1906	63,000	11,676	21,478,000	906	783	20,197	26,015
1907	79,810	16,647	24,274,260	(*f*) 954	1,107	23,345	32,764
1908	87,255	44,991	(*e*)2,073,907	(*f*)1,013	1,157	26,106	31,849
1909	79,786	57,768	(*e*)2,095,611	(*f*) 869	1,095	23,167	31,215
1910	105,453	20,100	(*e*)2,159,717	(*f*)1,118	1,406	28,034	34,623
1911	100,493	17,892	(*e*)2,187,246	(*f*)1,229	1,780	26,569	36,172
1912	103,923	27,960	(*e*)2,474,253	(*f*)1,567	2,116	29,908	44,756
1913	107,633	31,989	(*e*)2,482,424	(*f*)1,769	2,035	30,682	49,442
1914	....	40,762	(*e*)2,749,250	3,471	2,026	32,199	44,848

Year.	Iron and Steel *Continued.*						Lead in Pigs and Sheets.
	Anchors, Cables, and Chains.	Rails.	Nails, Spikes, and Screws.	Steel.	Sheets and Plates.	Other Manufactures.	
1902	2,103	15,316	2,205	1,754	36,288	22,069	(*c*)
1903	1,807	4,631	1,261	1,958	42,098	18,855	311
1904	2,109	5,814	1,071	1,610	42,013	5,462	498
1905	2,224	6,566	1,222	1,436	42,203	44,414	448
1906	2,585	8,086	1,012	2,018	48,969	45,959	727
1907	2,653	6,989	991	1,592	47,758	48,965	887
1908	2,535	12,180	1,032	1,628	49,569	52,594	529
1909	1,750	9,051	1,049	1,911	46,195	55,198	536
1910	2,131	5,512	852	3,203	56,898	60,282	838
1911	2,327	15,312	1,129	3,908	65,847	72,170	939
1912	2,591	12,276	1,313	4,239	84,525	86,552	1,142
1913	2,479	15.291	....	3,197	76,158	86,411	1,054
1914	2,651	21,834	....	2,739	73,006	98,928	1,079

Year.	Lead-white and Zinc Oxide.	Petroleum and Paraffin.	Potash.	Salt.	Salt-peter.	Soda.	Sulphur. (*b*)	Tin in Blocks, etc.	Zinc in Bars, Plates, etc.
1902	(*c*)	(*c*)	(*c*)	141,415	315	(*c*)	(*c*)	(*c*)	1,104
1903	(*c*)	58,822	457	143,110	245	4,200	8,829	106	1,015
1904	1,898	50,543	477	153,699	321	3,197	12,181	176	940
1905	1,309	43,860	393	137,800	1,048	3,704	10,240	134	967
1906	1,149	41,546	396	167,300	776	4,334	11,465	261	2,791
1907	1,245	44,231	588	163,458	1,004	5,819	11,412	332	3,549
1908	1,201	64,680	504	177,349	935	7,850	12,281	323	1,418
1909	1,304	63,042	475	164,195	572	8,357	10,293	280	1,336
1910	1,277	63,976	536	182,288	546	9,270	10,279	358	5,891
1911	1,465	71,496	524	192,354	786	9,566	8,782	353	9,173
1912	1,864	80,023	541	214,817	418	15,877	13,911	439	9,636
1913	2,502	79,253	572	214,987	522	16,255	15,411	333	13,560
1914	2,288	89,692	907	201,255	141	20,275	10,448	696	17,487

MINERAL EXPORTS OF NORWAY *(a)*
(In metric tons)

Year.	Apatite.	Copper.			Feldspar.	Iodine. *Kg.*	Iron.
		Ore.	Ingot.	Scrap.			Ore.
1902	2,295	4,848	1,913	(c)	(*d*)19,611	....	48,775
1903	1,795	3,448	1,930	888	(*d*)18,640	11,417	41,575
1904	1,456	2,673	1,124	785	20,835	9,414	45,434
1905	2,522	3,393	958	968	20,696	12,000	60,558
1906	3,482	84	875	964	19,669	13,248	81,398
1907	1,830	1,581	1,033	1,644	29,399	13,780	132,593
1908	1,771	156	1,260	385	29,896	11,097	110,425
1909	1,365	3,245	1,335	543	33,692	13,620	38,933
1910	703	241	1,377	583	39,507	13,114	88,715
1911	500	924	1,091	575	34,864	16,982	180,932
1912	....	423	1,551	366	39,844	11,642	404,990
1913	....	74	2,644	167	40,843	12,149	568,763
1914	....	0.1	2,345	676	27,703	2,320	456,925

Year.	Iron (*Continued*).				Nickel Ore.	Pyrite.	Zinc.
	Pig and Scrap.	Bars and Hoops.	Nails and Spikes.	Steel.			
1902	7,359	166	6,431	240	1	105,980	....
1903	6,350	10	6,504	200	*Nil.*	118,148	....
1904	10,152	13	7,477	167	30	116,550	....
1905	9,920	34	8,725	88	220	147,155	....
1906	7,362	8	6,786	21	*Nil.*	164,119	....
1907	4,652	7	5,879	31	11	187,983	....
1908	6,787	2	4,839	17	*Nil.*	218,851	....
1909	11,429	24	5,187	11	3	216,767	....
1910	13,455	5	6,878	34	....	343,073	....
1911	12,569	40	5,692	271	(*g*)385	343,850	....
1912	16,889	....	5,326	296	(*g*)594	424,121	....
1913	26,917	....	3,972	150	....	460,912	10,538
1914	14,498	....	3,804	1,274	(*g*)646	400,996	16,428

(a) From *Tabeller vedkommende Norges Bergvaerksdrift* and *Tabeller vedkommende Norges Handel.* (*b*) Includes flowers of sulphur. (*c*) Returns not available. (*d*) Includes a small quantity of fluorspar. (*f*) Includes a quantity of sheet aluminium. (*g*) Metallic nickel.

PORTUGAL

The subjoined table reports the mineral production of Portugal:

MINERAL PRODUCTION OF PORTUGAL (*a*)
(In metric tons)

Year.	Antimony Ore.	Arsenic Ore.	Coal (Anthracite). (*c*)	Copper.			
				Copper-Iron Pyrite. (*e*)	Other Ores.	Cement.	Matte.
1900	38	1,031	24,066	402,870	(*b*)	2,948	(*b*)
1901	(*b*)	527	16,000	443,397	(*b*)	2,061	(*b*)
1902	68	736	11,000	413,714	655	2,205	(*b*)
1903	83	698	8,063	376,177	527	2,448	(*b*)
1904	31	1,370	12,805	383,581	297	(*b*)	(*b*)
1905	84	1,562	11,449	352,479	210	2,148	(*b*)
1906	481	1,322	6,762	350,746	196	3,634	(*b*)
1907	383	1,538	8,824	241,771	2,478	2,942	298
1908	76	1,655	4,614	81,417	15,455	3,041	564
1909	6	1,420	6,274	12,337	1,321	3,037	309
1910	25	974	8,149	19,161	230	3,768	230
1911	....	887	10,610	15,287	517	3,979	283
1912	100	1,006	15,626	120,148	1,309	4,028	....
1913	19	925	25,087	13,550	....	4,177	....

Year.	Gold. *Kg.*	Iron Ore.	Lead Ore (Galena).	Manganese Ore.	Sulphur Ore.	Tin Ore and Metal.	Tungsten Ore.
1900	2.6	19,803	3,620	1,970	(*e*)	81	49
1901	2.0	21,599	445	904	(*e*)	31	90
1902	2.0	19,914	1,651	(*b*)	(*e*)	24	234
1903	1.3	15,200	830	30	(*e*)	(*b*)	228
1904	*Nil.*	12,488	291	(*b*)	(*e*)	51	290
1905	*Nil.*	3,200	50	(*b*)	(*e*)	20	358
1906	*Nil.*	(*b*)	511	22	(*e*)	22	570
1907	10.5	(*b*)	510	1,374	123,393	35	226
1908	57.0	(*b*)	481	(*b*)	24,522	28	106
1909	25.0	(*b*)	736	(*b*)	272,398	18	673
1910	4.1	3,360	919	(*b*)	293,745	9	948
1911	3.6	19,541	1,185	6	267,486	86	903
1912	3.5	35,210	495	6	481,295	173	1,227
1913	1.0	49,182	1,046	(*b*)	377,533	254	1,039

(*a*) From reports specially furnished *The Mineral Industry* by the Chief of the Department of Mines of the Ministerio das Obras Publicas, except for 1904 to 1906, inclusive, and 1913, which are from official Government reports. The mineral production of the country is identical with exports, except in the case of coal. (*b*) Not reported. (*c*) Consumed in the country. (*e*) Previous to 1907 the figures for "Sulphur Ore" (largely pyrite) were included under "Copper-Iron Pyrite."

RHODESIA

The statistics of the mineral production of Rhodesia for the last 12 years are given in the accompanying table.

MINERAL AND METALLURGICAL PRODUCTION OF RHODESIA (*a*)

Year.	Gold. *Oz.*	Value.	Silver. *Oz.*	Lead. *Tons.* (*b*)	Coal. *Tons.* (*b*)	Year.	Gold. *Oz.*	Value.	Silver. *Oz.*	Lead. *Tons.* (*b*)	Coal. *Tons.* (*b*)
1904...	267,737	$4,711,016	70,146	455	59,678	1910..	609,956	$12,657,791	217,633	749	180,068
1905...	407,048	7,046,692	89,278	570	97,191	1911..	628,521	12,991,500	187,641	639	212,529
1906...	551,894	9,647,581	110,575	652	103,803	1912..	642,807	13,174,058	176,532	587	216,140
1907 ..	612,052	10,589,385	147,324	756	115,073	1913..	689,954	14,261,343	142,390	327	243,328
1908 ..	606,962	12,276,394	283,424	1,069	164,114	1914..	854,480	17,423,087	150,793	168	349,459
1909..	623,388	12,985,430	262,133	965	170,893	1915..	915,029	18,603,973	186,233	......	409,763

(*a*) From report of Colonel Seely, Under-Secretary of State for the colonies. (*b*) Short tons.

RUSSIA

The mineral and metallurgical production of Russia, according to the best statistics available to MINERAL INDUSTRY, is given in the subjoined tables.

MINERAL AND METALLURGICAL PRODUCTION OF RUSSIA (*a*)

(In metric tons; 1 metric ton = 61.05 poods)

Year.	Asbestos.	Chrome Ore.	Coal.	Copper.	Gold. (*b*)	Pig Iron.	Lead.	Manganese Ore.
1900..	3,845	18,233	16,156,055	8,258	$22,369,864	2,933,786	220.7	802,236
1901..	4,398	22,169	16,526,652	8,467	22,763,967	2,866,779	156.0	522,395
1902..	4,508	19,656	16,465,852	8,817	22,258,343	2,598,086	225.3	536,519
1903..	5,264	16,421	17,868,515	9,232	24,147,222	2,487,783	106.3	414,334
1904..	7,502	26,575	19,608,631	9,835	24,627,537	2,972,115	90.3	430,090
1905..	5,896	27,051	18,727,766	8,515	20,521,587	2,628,101	700.2	508,635
1906..	9,197	16,969	21,593,158	9,296	20,020,862	2,694,895	906.8	1,015,686
1907..	9,398	(*g*)26,357	25,741,321	15,930	26,518,253	3,041,570	520.0	(*g*)1,003,528
1908..	10,911	(*g*)10,950	(*g*)25,903,560	17,118	33,143,810	2,818,450	522.5	362,303
1909..	(*h*)13,129	22,213	24,532,349	19,656	31,889,956	2,889,353	.....	574,938
1910..	(*h*)10,936	1,362	(*f*)23,105,628	(*f*)22,619	(*f*) 35,566,045	(*f*)3,042,046	.....	668,050
1911..	17,071	1,238	28,007,239	(*f*)25,097	(*f*) 34,550,609	3,593,000	.....	(*i*) 636,180
1912..	18,138	21,277	30,641,163	33,513	28,852,881	3,726,000	.....	903,226
1913..	18,594	....	32,206,000	34,282	22,199,000	3,801,273	.....	1,130,000
1914..	....	....	....	32,250	....	....	.....	....
1915.	....	....	....	35,470	....	....	.....	....

Year.	Petroleum.	Phosphate Rock.	Platinum. *Kg.*	Pyrite.	Quicksilver.	Salt.	Silver. *Kg.*	Sulphur.	Zinc.
1899..	8,517,608	16,863	5,962	23,250	362	1,679,726	4,419	451	6,326
1900..	9,844,390	25,663	5,089	23,154	141	1,968,007	2,293	1,587	5,963
1901..	10,925,471	21,276	6,371	30,732	363	1,705,924	1,088	2,489	6,104
1902..	10,445,536	13,709	6,135	26,465	416	1,847,021	1,200	1,800	8,264
1903..	9,759,214	14,635	6,009	22,780	362	1,658,938	1,152	281	9,894
1904..	10,058,968	20,282	5,016	31,667	332	1,908,275	726	16	10,612
1905..	7,505,637	20,585	5,250	30,689	318	1,844,678	2,965	16	7,911
1906..	8,167,934	18,970	5,776	20,660	210	1,730,934	430	39	9,602
1907..	9,098,931	(*g*)15,457	5,903	18,316	(*g*)132	1,873,171	7,843	(*d*)57	10,409
1908..	8,732,301	(*g*)14,976	4,883	56,345	147	1,879,717	9,595	(*d*)85	9,960
1909..	8,961,507	(*h*)21,326	5,120	(*j*)46,078	....	2,259,690	(*h*)15,415	....	7,644
1910..	8,952,793	(*h*)24,883	5,471	(*j*)55,980	....	2,047,980	(*h*)14,841	....	(*f*)8,631
1911..	9,152,315	(*h*)25,503	(*f*)5,432	113,054	....	2,013,765	15,512	....	(*f*)9,652
1912..	9,249,600	....	5,523	123,990	....	....	....	....	....
1913..	9,474,876	....	5,287	....	....	....	....	....	....
1914..	9,099,494	....	....	....	....	....	....	....	....

(*a*) From official sources. (*b*) The value of gold is taken at $20.67 per ounce. (*d*) Includes sulphide ore. (*f*) Statistics of Association of Russian Manufacturers and Traders. (*g*) St. Petersburg Scientific Committee. (*h*) The Russian Year Book, Dr. Kennard, London. (*i*) Exports. (*j*) *Mineral Resources of U. S.*

SOUTH AMERICA

The following tables itemize the statistics of the production and the foreign commerce, or both, of mineral and metallurgical products of South American countries so far as available. No statistics later than those given in the tables have been published. Figures in full-faced type are either provisional figures or estimates.

MINERAL AND METAL PRODUCTION OF BOLIVIA (*a*)

(In metric tons)

Year.	Antimony Ore.	Bismuth. Metal.	Bismuth. Ore.	Copper Ore.	Copper. (*c*)	Gold. (*b*)	Silver. (*d*)	Tin Ore.	Tungsten Ore.
1907....	2,279	249	153.379	....	3,469	$3,551	3,696	27,668	(*e*)500
1908....	734	259	160.305	....	3,027	21,617	156.5	29,938	170
1909....	....	89	236.762	....	3,097	....	155.4	35,566	170
1910....	....	97	311.060	....	3,212	....	143	38,548	207
1911....	312	....	1,208.689	....	2,950	22,313	128.0	37,073	297
1912....	91	(*g*)478	....	....	4,707	23,038	123.9	38,614	472
1913....	62	391	32	....	4,020	**175,000**	81.3	44,597	283
1914....	186	....	....	4,793	3,874	....	....	37,259	276
1915....	**17,923**	**568**	....	**17,944**	**5,839**	....	....	**36,324**	**755**

(*a*) From a British Consular report and Revista de Aduanas. (*b*) Reduced to U. S. currency. (*c*) Includes ingots, precipitate, matte and concentrate. (*d*) Includes ingots, ore, and sulphide. (*e*) U. S. Geol. Surv. (*g*) Metal and metal content of ore.

MINERAL EXPORTS OF BRAZIL (*a*)

(In metric tons or dollars) (*d*)

Year.	Agate.	Carbonado. *Carats*	Copper Ore. *Carats.*	Diamonds. *Carats.*	Gold.	Manganese Ore.	Mica and Talc.	Monazite.	Platinum *Grams.*	Precious Stones. (*b*)	Rock Crystal.
1907..	53	363,200	(*c*)	110,457	$1,976,000	236,778	$8,176	4,438	*Nil*	$33,335	37
1908(*e*)	79	126,380	(*c*)	97,090	2,187,950	166,122	5,540	4,965	*Nil*	109,150	36
1909(*e*)	......	177,572	(*c*)	58,862	2,252,900	240,774	.....	6,462	*Nil*	56,338	....
1910(*e*)	34	13,848	(*c*)	14,366	1,954,674	253,953	.....	5,437	*Nil*	745	....
1911(*e*)	112	63,400	1	103,567	2,850,370	173,941	9	371	*Nil*	135,220	24
1912(*e*)	103	47,998	....	139,175	2,676,950	154,870	11.5	3,398	*Nil*	74,597	45
1913..	......	....	....	....	2,692,154	122,300	......	1,437	....	174,066	....
1914..	......	....	....	....	2,127,515	183,600	......	609	....	21,022	....
1915..	......	....	....	....	2,390,719	288,671	......	439	....	44,024	....

(*a*) As reported by the *Brazilian Review.* (*b*) Other than carbonado and diamonds. (*c*) Statistics not available. (*d*) The par exchange value of the *Mil Reis* in 1907 was $0.546 U.S. gold. Common exchange value was in 1902, $4.155; in 1903, $4.134; in 1904, $4.146; in 1905, $3.153; in 1906, $3.103, and in 1907, $3.301. (*e*) Reported by U. S. Consul at Rio de Janeiro.

MINERAL PRODUCTION OF CHILE (*a*)
(In metric tons)

Year.	Borax.	Coal.	Iron Ore.	Copper.	Gold. *Kg.*	Guano.	Iodine.	Salt.	Silver. *Kg.*	Sodium Nitrate.	Sulphur.
1902..	....	....	....	27,066	1,286	(*f*)	242	9,532	57,418	1,400,408	2,636
1903..	16,879	827,112	....	29,923	994	11,134	387	16,264	28,552	1,444,920	3,560
1904..	16,733	751,628	....	31,025	1,135	2,669	461	17,674	28,501	1,487,598	3,594
1905..	19,612	793,927	....	29,126	1,055	19,380	564	12,108	16,315	1,669,806	3,470
1906..	28,996	932,488	....	25,829	1,135	4,709	331	17,116	12,211	1,822,144	4,598
1907..	28,374	832,612	....	28,863	1,907	7,518	4,202	18,982	18,736	1,846,036	2,905
1908..	35,039	939,836	....	42,097	1,189	871	330	16,257	43,569	1,970,974	2,705
1909..	32,218	898,971	....	42,726	1,268	10,692	474	20,463	35,907	2,110,961	4,508
1910..	35,192	1,074,174	....	38,232	1,088	12,683	581	23,361	34,958	2,465,415	3,823
1911..	45,558	1,188,053	....	36,420	437	17,841	437	23,720	27,675	2,521,023	4,451
1912..	43,356	1,334,407	....	41,647	1,101	18,266	458	17,045	30,178	2,585,850	4,431
1913(*e*)	....	....	....	42,264	......	......	437	....	....	2,666,835	......
1914(*e*)	34,203	266,962	63,505	45,682	......	......	489	....	....	1,846,783	......
1915(*e*)	....	....	....	45,022	......	......	......	....	....	2,023,562	......

(*a*) From *Estadistica Minera de Chile.* (*b*) The combined output of the years 1894 to 1902, inclusive was 86,892 tons.. (*c*) The combined output of Chile up to the end of 1902 is estimated at 20,650,000 tons. (*e*) Exports. (*f*) The combined output of Chile up to the end of 1902 is estimated at 163,704 tons, valued at 5,041.560 pesos ($1,840,169).

MINERAL AND METAL PRODUCTION OF PERU (*a*)
(In metric tons)

Year.	Bismuth.	Borate.	Coal. (*b*)	Copper.	Gold. *Kg.*	Lead.	Nickel. *Kg.*	Petroleum.	Quicksilver. *Kg.*	Silver. *Kg.*	Salt.	Sulphur.
1907...	48	2,451	185,565	20,681	777.6	5,525	....	100,184	1,500	207,810	21,592	1,880
1908...	9	2,870	311,122	19,854	977.0	2,633	....	125,948	1,822	195,404	21,899	......
1909...	30	2,715	321,502	26,068	554.0	2,093	....	188,128	350	207,656	22,715	.....
1910...	24	2,351	307,320	27,347	708.0	1,866	....	167,712	350	252,565	17,594	.....
1911...	24	1,923	324,000	27,735	741.2	2,208	....	195,276	560	289,383	24,867	......
1912...	51	1,674	278,927	26,970	1,435.0	4,050	....	233,600	400	324,352	23,292	......
1913...	25	2,001	273,945	27,776	1,435.0	3,927	....	276,147	460	299,132	24,433	......
1914...	......	......	....	....	**670.0**	......	....	....	....	....	....	......

(*a*) Reported by the Cuerpo de Ingenieros de Minas del Peru, in its *Boletin.* (*b*) Includes asphaltum and bituminous schist.

SPAIN

The following tables record the mineral and metal production of Spain as reported by official authorities:

MINERAL PRODUCTION OF SPAIN (*a*)
(In metric tons)

Year.	Aluminous Earths.	Antimony Ore.	Arsenic.	Asphaltum.	Asphalt, Rock.	Barytes.	Cement, Hydraulic.	Coal.	
								Anthracite.	Bituminous.
1900...	420	30	150	2,331	4,193	833	185,811	68,427	2,514,545
1901...	305	10	120	4,182	3,956	1,067	189,909	85,266	2,566,591
1902...	337	67	*Nil.*	6,034	6,301	642	201,856	109,298	2,614,010
1903...	381	42	1,088	4,675	6,277	507	245,294	108,959	2,587,652
1904...	925	245	400	3,463	3,761	453	286,737	163,275	2,903,771
1905...	221	77	1,140	5,805	5,725	290	296,605	159,517	2,912,466
1906...	386	180	1,114	6,229	7,794	330	299,294	113,747	3,095,043
1907...	1,209	205	1,500	8,643	8,219	314	329,926	164,498	3,531,337
1908...	60	124	2,004	9,231	12,373	334	343,001	188,463	3,696,653
1909...	35	(*b*)	506	6,582	5,284	422	472,909	198,302	3,662,573
1910(*f*)	400	15	444	8,473	7,795	476	484,161	211,958	3,600,056
1911...	461	100	331	3,495	6,500	635	486,085	209,227	3,454,394
1912(*h*).	....	500	....	5,387	....	1,096	....	226,663	3,625,666
1913(*i*).	....	....	....	5,582	....	3,049	....	232,517	3,783,214

Year.	Coal (*Continued*).		Coke.	Copper Ore.		Copper.			Fluorspar.
	Lignitic.	Briquets.		Argentiferous.	Pyritic.	Fine.	Matte.	Precipitate.	
1900...	91,133	341,156	381,000	2,006	2,714,714	5	18,159	29,652	4
1901...	95,867	338,684	455,586	(*b*)	2,672,365	79	15,634	28,433	(*b*)
1902...	84,242	331,957	404,503	878	2,617,776	(*b*)	.....	36,045	93
1903...	104,232	339,120	433,780	3,056	2,796,733	(*b*)	.....	27,448	4,000
1904...	100,773	307,630	432,726	(*b*)	2,624,512	(*b*)	8,117	29,494	(*b*)
1905...	168,994	290,830	448,073	(*b*)	2,621,054	(*b*)	8,243	17,988	(*b*)
1906...	189,048	311,328	435,808	(*b*)	2,888,778	(*b*)	9,068	19,200	70
1907...	191,001	355,718	476,360	(*b*)	3,182,645	(*b*)	9,886	20,887	270
1908...	223,160	296,216	477,059	(*b*)	2,985,779	(*b*)	205	19,599	253
1909...	265,019	(*b*)	500,909	(*b*)	2,955,254	(*b*)	2,077	16,641	246
1910(*f*)	245,518	474,891	521,078	(*b*)	3,231,418	85	2,684	14,056	180
1911...	252,051	478,143	516,342	(*b*)	3,284,184	(*g*)76	1,910	12,353	499
1912(*h*).	283,480	465,106	489,558	....	3,366,165	......	1,861	....	265
1913(*i*).	276,791	486,228	595,677		2,265,642	......	3,049	....	351

Year.	Iron Ore.		Iron and Steel.			Kaolin (China Clay).	Lead (Argentiferous).	
	Argentiferous.	Non-argentiferous.	Pig.	Wrought Iron.	Iron and Steel, Worked.		Ore.	Metal.
1900...	26,348	8,675,749	91,126	54,307	144,355	3,794	182,016	74,341
1901...	27,726	7,906,517	135,600	47,085	121,023	2,220	207,188	73,895
1902...	24,361	7,904,555	330,747	....	163,564	3,412	227,645	74,370
1903...	90,996	8,304,153	380,284	....	199,642	2,578	179,858	56,687
1904...	122,109	7,964,748	283,819	50,858	186,705	1,700	177,104	57,956
1905...	152,027	9,007,245	305,462	11,366	223,545	720	160,381	56,361
1906...	126,445	9,448,533	315,309	6,035	274,280	610	158,425	53,856
1907...	(*b*)	9,896,178	355,240	14,767	310,125	640	165,289	51,430
1908...	(*b*)	9,271,592	403,554	21,807	262,843	1,370	165,382	53,741
1909...	3,813	8,786,021	428,622	24,187	218,410	570	161,496	43,552
1910(*f*)	46,161	8,666,795	373,322	59,133	201,798	1,496	150,592	38,548
1911...	....	8,773,691	408,667	11,166	264,930	4,469	156,569	40,379
1912(*h*).	1,588	9,133,007	366,136	....	....	4,920	93,850	49,212
1913(*i*).	....	9,861,668	350,433	....	....	5,263	23,600	15,704

Year.	Lead (Non-argentiferous).		Manganese Ore.	Mineral Paints (Ocher).	Phosphate Rock.	Pyrites (Iron).	Pyrites (Arsenical).	Quicksilver.	
	Ore.	Metal.						Ore.	Metal.
1900 ...	131,437	98,189	112,897	58	4,170	34,638	515	30,216	1,095
1901 ...	174,376	95,399	60,325	164	4,220	33,953	1,328	23,367	754
1902 ...	100,403	103,190	46,069	(b)	1,150	145,173	5,648	26,037	1,425
1903 ...	108,660	118,422	26,194	(b)	1,124	155,739	7,996	30,370	968
1904 ...	93,230	127,906	18,732	(b)	3,305	161,841	3,510	27,185	1,130
1905 ...	105,113	129,332	26,020	(b)	1,370	179,079	4,790	26,485	853
1906 ...	105,095	131,614	62,822	164	1,300	189,243	2,434	28,965	1,568
1907 ...	103,632	135,066	41,504	114	3,547	225,830	3,423	28,789	1,212
1908 ...	126,667	134,321	16,745	400	4,483	263,451	5,533	42,210	1,068
1909(f).	137,050	136,441	7,827	418	1,387	258,931	3,235	37,398	1,393
1910...	216,738	151,975	8,607	759	2,840	294,184	1,461	22,714	1,114
1911...	165,843	149,540	5,607	622	3,520	344,879	1,056	19,940	1,494
1912(h).	190,162	183,400	17,400	....	3,292	421,070	....	21,889	1,256
1913(i).	279,078	173,125	21,594	....	3,548	926,913	....	19,960	1,246

Year.	Salt.	Silver.		Soapstone.	Sulphur.		Tin Ore, Dressed.	Topaz. *Kg.*	Tungsten Ore.	Zinc.		
		Ore.	Metal. *Kg.*		Crude Rock.	Refined.				Ore.	Spelter.	Sheets.
1900..	450,041	742	140,457	8,109	64,364	750	47	95	1,958	86,158	2,855	2,756
1901..	345,063	391	94,977	4,880	49,856	610	115	310	6	119,708	2,573	2,781
1902..	426,434	175	96,975	542	15,442	450	12,762	*Nil.*	11	127,618	5,569	(b)
1903..	427,394	231	112,978	3,725	38,573	1,608	330	90	*Nil.*	154,126	5,134	(b)
1904..	543,658	303	117,418	5,165	40,389	605	229	....	60	156,329	5,887	2,913
1905..	493,451	540	123,607	4,364	38,153	610	209	....	375	160,561	6,184	2,936
1906..	541,978	470	126,424	3,609	28,965	700	86	171	430	170,384	6,209	2,639
1907..	605,895	702	127,435	13,875	27,054	3,612	315	266	386	191,853	6,144	2,485
1908..	822,677	441	129,881	4,730	13,872	2,988	838	(b)	226	156,233	6,357	2,693
1909(f	800,703	388	143,403	5,583	21,750	3,429	(e)1,555	(b)	129	163,522	9,625	(b)
1910..	678,057	217	129,157	4,665	30,113	3,834	35	149	153	156,113	8,557	2,722
1911..	654,767	858	110,082	5,647	40,662	6,580	34	......	96	162,140	2,904	3,429
1912(h	23,292	668	143,400	....	42,344	4,592	5,079	......	169	175,311	8,451	......
1913(i	26,238	405	266,606	....	62,653	7,499	6,626	......	235	174,831	7,935	......

(a) Figures are from *Estadistica Minera de España*, except for 1896 and 1898, which were from the official *Reports of the Junta Superior Facultativa de Minas* Madrid. (b) Not reported. (e) Undressed tin ore. (f) *Revista Minera*, June 24, 1911. (g) Blister copper 18,295 tons, copper sulphate 15,893 tons. (h) *Revista Minera*, Apr. 24, 1914. (i) *Revista Minera*, Feb. 24, 1915.

SWEDEN

The official statistics of mineral production, imports and exports, are summarized in the following tables:

MINERAL PRODUCTION OF SWEDEN (*a*)
(In metric tons)

Year.	Alum.	Coal.	Copper. Ore.	Copper. Ingot.	Copper. Sulphate.	Feldspar.	Graphite.	Gold. *Kg.*
1902.....	132	304,733	30,095	178	1,257	17,960	63	94.3
1903.....	140	320,390	36,687	776	1,171	19,392	25	50.6
1904.....	125	320,984	36,834	533	1,248	18,021	55	60.9
1905.....	139	322,384	39,255	1,385	1,029	19,224	40	55.0
1906.....	167	296,980	19,655	1,209	562	21,014	37	20.3
1907.....	131	305,338	21,957	1,577	782	20,244	33	28.1
1908.....	138	305,206	21,371	2,808	731	17,494	66	20.3
1909.....	132	246,808	9,562	2,375	628	15,772	26	14.1
1910.....	182	302,786	3,638	3,111	20	21,591	49	2.0
1911.....	159	311,809	1,623	3,221	320	36,235	65	11.0
1912.....	145	360,291	3,059	3,957	870	34,305	79	30.5
1913.....	144	363,965	5,458	6,891	428	37,878	88	25.0
1914.....		366,639	8,839	4,692	158	20,818	56	84.0

Year.	Iron and Steel. Ore.	Iron and Steel. Pig.	Iron and Steel. Blooms.	Iron and Steel. Bars, Rods, Sheets, etc.	Iron and Steel. Iron Sulphate.	Steel. Bessemer.	Steel. Basic.	Steel. Crucible.
1902....	2,896,208	538,113	186,076	(*b*)	127	84,014	201,311	1,091
1903....	3,677,520	506,825	192,342	325,200	62	84,229	232,878	1,105
1904....	4,083,945	528,525	189,246	324,676	148	78,577	252,832	1,162
1905....	4,364,833	539,437	182,640	356,898	144	78,204	288,675	1,319
1906....	4,501,656	604,789	178,298	381,118	170	84,633	311,435	1,457
1907....	4,478,917	615,778	174,405	403,994	159	77,036	341,893	1,287
1908....	4,712,494	567,821	152,256	363,408	277	81,054	355,394	1,169
1909....	3,885,046	444,764	120,669	292,478	182	63,351	248,757	927
1910....	5,549,987	603,929	151,713	408,191	236	97,503	372,451	2,215
1911....	6,150,718	634,392	146,722	408,159	156	93,853	372 705	4,309
1912....	6,699,226	699,816	....	....	....	107,254	307,637	....
1913....	7,475,571	730,257	....	....	320	**115,700**	467,100	....
1914....	6,586,630	639,718	241,652	500,827	651	93,210	409,528	2,826

Year.	Lead.	Manganese Ore.	Pyrite.	Silver-Lead Ore.	Silver. *Kg.*	Sulphur.	Zinc Ore.
902.......	843	2,850	*Nil.*	9,378	1,365	74	48,630
1903.......	678	2,244	7,793	9,792	1,005	(*b*)	48,783
1904.......	589	2,297	15,957	8,187	651	35	62,927
1905.......	576	1,992	20,762	8,397	606	0	57,634
1906.......	753	2,680	21.827	1,938	938	0	56,885
1907.......	813	4,334	27,113	1,987	929	0	52,552
1908.......	277	4,616	29,569	2,058	630	0	50,884
1909.......	166	5,212	16,104	1,721	512	0	40,077
1910.......	355	5,752	25,445	2,700	30	0	43,760
1911.......	1,134	5,377	30,096	2,999	1,289	0	49,453
1912.......	1,073	5,101	31,835	2,877	962	....	51,242
1913.......	1,235	4,001	34,319	3,222	1,037	....	50,752
1914.......	1,396	3,643	33,313	3,110	1,074		42,279

(*a*) From *Bidrag till Sveriges Officiela Statistik Bergshandteringen.* (*b*) Not reported.

MINERAL IMPORTS OF SWEDEN (*a*)
(In metric tons or dollars; 1 krone = 27 cents)

Year.	Asbestos. (*c*)	Asphalt.	Barytes.	Borax.	Boric Acid.	Bromine and Bromides. *Kg.*	Cement.	Chalk, White, Unground. *Hectoliters.*	Coal.
1900....	763	5,676	411	194	66	6,084	1,941	12,059	3,033,885
1901....	178	4,524	295	253	68	6,602	2,868	13,569	2,793,309
1902....	213	5,779	....	242	71	7,278	9,822	11,583	2,911,286
1903....	217	5,957	....	240	71	7,419	11,145	41,868	3,192,990
1904....	356	6,243	....	299	77	10,128	10,526	10,115	3,367,826
1905....	140	4,760	264	294	82	18,788	10,999	13,305	3,297,485
1906....	287	7,134	559	321	79	9,908	13,136	10,777	3,718,884
1907....	672	8,213	610	490	85	6,784	17,801	(*g*) 860	4,146,785
1908....	505	6,368	514	347	71	11,499	6,158	(*g*) 419	4,427,507
1909....	383	7,922	529	365	76	10,280	12,944	(*g*) 512	4,084,055
1910....	671	7,406	625	379	92	10,913	15,438	(*g*) 473	4,180,250
1911....	1,011	6,803	607	381	76	16,819	24,830	(*g*) 605	3,964,870
1912....	635	7,645	644	434	199	9,319	17,438	(*g*) 422	4,293,719
1913....	1,094	6,809	610	470	120	11,211	12,120	(*g*) 2,337	4,878,854

Year.	Copper, also Alloys of Copper.	Emery.	Graphite.	Gypsum.	Iron, Crude.	Lead.	Litharge.	Phosphorus. *Kg.*	Platinum. *Kg.*
1900....	4,745	136	213	6,794	82,957	2,067	148	67,557	59
1901....	5,153	169	180	6,589	66,131	1,991	165	70,672	172
1902....	6,890	147	(*b*)	6,754	43,828	2,509	172	68,441	130
1903....	6,109	132	(*b*)	8,795	49,411	2,644	237	112,659	116
1904....	7,367	221	(*b*)	8,868	90,102	2,849	213	47,421	84
1905....	6,481	271	(*b*)	11,270	87,843	2,823	205	69,526	105
1906....	8,899	284	(*b*)	13,496	108,193	3,457	255	79,048	133
1907....	(*c*) 14,213	336	375	15,037	115,186	3,384	210	77,936	109
1908....	(*c*) 12,392	308	540	11,644	109,841	3,964	248	107,301	117
1909....	(*c*) 11,000	428	443	14,212	99,519	3,222	217	88,241	72
1910....	(*c*) 13,297	438	398	15,816	117,180	3,453	267	99,145	77
1911....	(*c*) 14,014	459	398	14,505	114,859	2,901	270	77,837	103
1912....	7,470	490	513	10,467	140,145	1,204	316	88,411	12
1913....	9,189	667	576	13,284	102,744	2,676	327	92,487	23

Year.	Potassium.				Quicksilver. *Kg.*	Salt.		Silver.	
	Chloride.	Cyanide. *Kg.*	Hydrate.	Carbonate.		Crude.	Refined.	Bullion and Mfrs. *Kg.*	Specie.
1900......	364	2,221	1,915	1,257	3,629	70,302	3,098	11,559	$62,315
1901.....	260	2,658	1,435	1,266	5,958	79,038	3,072	7,476	78,416
1902....	222	2,950	1,720	1,238	4,866	82,439	3,037	4,853	74,826
1903.....	245	3,294	2,034	1,150	5,043	88,139	3,419	11,259	90,366
1904.....	214	3,237	2,234	1,184	5,768	84,237	4,615	19,034	86,891
1905.....	1,296	3,437	2,251	1,133	4,609	87,677	3,889	11,067	82,620
1906.....	1,986	4,106	2,486	1,082	5,535	88,341	3,700	15,253	93,990
1907.....	1,840	4,150	2,484	1,269	8,930	(*h*) 835,190	18,821	26,334	52,074
1908.....	2,190	3,563	2,835	1,209	7,299	(*h*) 903,633	24,394	20,149	93,669
1909.....	1,809	3,808	2,627	1,312	6,077	(*h*) 766,195	24,143	17,315	154,265
1910....	2,335	4,272	2,767	1,346	7,079	(*h*) 766,512	22,425	21,162	75,604
1911.....	1,288	4,993	3,737	1,268	4,164	(*h*) 736,935	26,026	15,175	134,407
1912.....	228	7,545	(*i*)3,262	1,380	5,110	1,050	22,009	21,220	164,781
1913.....	2,081	7,607	(*i*)5,234	1,417	5,142	911	24,927	20,550	....

Year.	Sodium.				Sulphur.	Sulphuric Acid.	Tin.		Zinc.
	Carbonate.	Hydrate.	Nitrate. (d)	Sulphate. (e)			Salts. *Kg.*	Block.	
1901....	13,669	800	17,614	15,494	20,715	1,950	2,334	541	2,900
1902....	....	1,623	15,553	18,924	23,002	1,887	1,652	644	3,255
1903....	....	1,426	20,616	16,120	24,577	2,620	1,467	655	3,312
1904....	11,898	2,112	19,776	17,596	18,248	2,001	1,460	719	3,705
1905....	13,592	1,489	23,183	17,115	18,631	3,424	1,722	597	3,780
1906....	14,974	1,478	27,174	19,948	22,745	2,535	1,102	819	4,484
1907....	14,970	1,628	26,181	21,486	25,456	2,628	6,117	891	5,407
1908....	14,149	1,256	27,631	18,717	30,806	3,073	2,817	808	4,626
1909....	13,490	1,119	28,849	20,226	26,836	1,955	1,357	794	5,294
1910....	15,594	1,260	32,315	22,429	38,530	2,707	1,161	764	5,843
1911....	15,777	2,501	31,324	27,482	34,622	861	915	866	5,951
1912....	18,255	....	35,107	26,540	38,471	593	73,045	1,032	4,617
1913....	18,473	....	33,891	31,740	39,715	1,114	56,982	1,083	3,699

MINERAL EXPORTS OF SWEDEN (*a*)
(In metric tons or dollars; 1 krone = 27 cents)

Year.	Alum.	Ammonium Sulphate.	Antimony, Crude. *Kg.*	Asbestos. *Kg.*	Cement.	Coal (Anthracite).	Copper.		Graphite
							Ore.	Copper and Alloys.	
1899 ...	26	2	2,600	2,812	31,101	762	315	1,230	17
1900 ...	24	2	4,600	2,436	42,564	1,108	448	2,012	18
1901 ...	56	156	1,800	2,179	17,794	716	602	1,243	19
1902 ...	20	174	4,090	1,864	19,499	866	845	1,516	5
1903 ...	22	*Nil.*	3,473	15,357	21,319	509	1,555	1,858	9
1904 ...	9	219	3,810	16,339	27,509	605	749	1,396	(*b*)
1905 ...	12	445	3,147	2,386	38,504	425	2,137	2,654	(*b*)
1906 ...	11	30	4,584	1,510	45,960	1,352	1,841	2,662	(*b*)
1907 ...	7	*Nil.*	4,485	2,167	18,053	2,925	882	2,762	8
1908 ...	9	202	4,188	1,612	34,164	1,293	1,114	3,299	18
1909 ...	5	331	6,536	1,093	33,197	771	723	3,264	7
1910 ...	11	704	4,555	1,242	73,351	776	878	2,580	7
1911 ...	2	253	7,320	760	108,653	1,045	1,114	2,500	12
1912 ...	15	42	9,151	564	127,142	684	1,577	4,273	9
1913 ...	6	254	6,803	1,066	137,074	419	1,709	3,495	48

Year.	Gypsum and Mfrs.	Iron and Steel.		Lead and Mfrs.	Peat.	Phosphorus. *Kg.*	Potassium Chloride.
		Ore.	Unwrought.				
1899........	8	1,628,011	320,742	818	1,979	1,890	335
1900........	10	1,619,902	304,175	1,209	3,843	879	931
1901........	55	1,761,257	268,143	1,028	3,064	1,254	708
1902........	117	1,729,000	(*f*) 73,403	546	3,620	1,290	1,114
1903........	119	2,828,000	(*f*) 70,788	333	3,217	300	790
1904........	162	3,065,522	(*f*) 88,124	275	4,212	1,994	1,266
1905........	156	3,316,626	(*f*)120,987	512	5,157	34,388	1,499
1906........	6	3,661,218	(*f*)112,719	531	6,531	700	(*b*)
1907........	16	3,521,717	201,643	519	6,524	(*b*)	(*b*)
1908........	37	3,654,268	159,095	496	5,559	400	1,363
1909........	21	3,204,522	161,757	319	9,999	1,305	1,400
1910........	41	4,434,805	213,861	557	9,754	265	1,383
1911........	13	5,086,898	226,044	1,181	10,371	595	1,564
1912........	2	5,520,653	213,619	1,003	7,276	600	1,653
1913........	1	6,413,644	216,013	745	7,135	900	1,423
1914........							

Year.	Salt, Refined. *Kg.*	Silver Bullion. *Kg.*	Soda (Carbonate).	Sulphur.	Tin.		Zinc.	
					Block and Scrap.	Mfrs. *Kg.*	Ore.	Crude and Mfrs.
1899....	110	367	227	68	8.8	1,033	45,635	157
1900....	407	296	238	20	21.5	1,521	40,879	157
1901....	1,556	179	237	12	20.4	8,110	41,248	101
1902....	1,945	110	621	147	25.5	1,603	43,813	63
1903....	*Nil.*	484	10	217	43.3	3,893	45,389	351
1904....	1,883	115	45	4	45.6	3,479	44,259	332
1905....	*Nil.*	10	403	4	33.9	654	51,765	295
1906....	8,652	77	463	12	51.0	353	45,380	410
1907....	4,452	160	39	1	67.9	2,518	41,236	529
1908....	14,300	136	114	7	53.9	274	38,543	908
1909....	6,422	437	27	5	42.5	276	38,865	1,200
1910....	1,326	814	31	6	51.1	356	40,405	1,278
1911....	3,450	1,090	40	7	66.0	152	41,854	2,158
1912....	1,668	2,021	3	75	110.0	698	41,985	3,136
1913....	6,916	4,300	2	239	87.0	2,640	46,696	6,533

(*a*) From *Bidrag till Sveriges Officiella Statistik* and *Sveriges Utförsel och Införsel.* (*b*) Not reported. Includes crude and manufactures. (*d*) Includes a small quantity of potassium nitrate. (*e*) Includes sodium bisulphate. (*f*) Includes only crude or ballast iron. (*g*) Metric tons. (*h*) Hectoliters. (*i*) Includes sodium hydroxide.

UNITED KINGDOM

The statistics of the mineral production, imports and exports, according to official reports, are given in the subjoined tables. Figures given in full-faced type are either provisional figures or estimates.

MINERAL AND METALLURGICAL PRODUCTION OF THE UNITED KINGDOM (*a*)
(In metric tons)

Year.	Alum Shale.	Arsenious Acid.	Arsenical Pyrites.	Barium Minerals.	Bauxite.	Chalk.	Clay. (*e*)	Coal.
1903....	3,337	916	58	24,659	6,226	4,541,494	16,460,526	234,019,821
1904....	6,636	992	44	26,748	8,839	4,509,768	16,210,734	236,130,373
1905....	7,245	1,552	651	29,528	7,417	4,608,153	15,376,910	239,906,999
1906....	9,605	1,625	650	36,319	6,760	4,825,299	12,459,213	255,067,622
1907....	10,063	1,523	1,800	42,648	7,658	4,855,857	15,065,141	272,097,858
1908....	5,459	2,007	3,270	39,572	11,904	4,329,983	14,638,710	265,726,332
1909....	9,266	2,926	182	42,436	9,652	4,508,136	14,293,598	268,007,890
1910....	6,781	2,187	958	45,384	4,208	4,705,766	(*h*)14,316,469	268,677,182
1911....	10,685	2,178	1,189	44,826	6,103	5,965,423	14,057,090	276,255,764
1912....	11,446	2,228	1,806	43,453	5,882	4,962,408	13,022,433	264,749,661
1913....	8,887	1,716	36	48,792	6,153	4,939,095	14,090,818	292,047,544
1914....	6,179	2,007	(*b*)	46,675	8,421	4,362,689	13,343,100	270,070,414
1915....	....	2,537	15	61,794	11,914	....	....	257,310,322

Year.	Copper.		Fluorspar.	Gold.		Gravel and Sand.	Gypsum.	Bog Ore (Ireland). (*c*)
	Ore and Precipitate.	Fine.		Ore.	Bullion. *Kg.*			
1903......	6,977	545	12,102	29,057	171.0	2,281,689	223,426	4,156
1904......	5,552	501	18,450	23,574	610.7	2,275,426	237,749	4,616
1905......	7,267	727	40,079	16,237	169.0	2,277,486	259,596	3,256
1906......	7,882	(*b*)	42,521	17,662	(*b*)	2,404,857	228,627	5,512
1907......	6,867	677	50,257	13,186	59.4	2,438,798	239,285	6,391
1908......	5,528	588	35,257	7,237	28.5	2,228,245	231,980	4,364
1909......	3,777	442	43,165	5,627	37.6	2,199,583	242,832	2,719
1910......	4,245	456	62,607	6,252	75.5	2,235,160	259,661	2,603
1911......	3,314	398	56,117	2,796	13.2	2,311,694	281,125	2,743
1912......	1,942	296	29,154	173	49.7	2,227,975	247,724	3,397
1913......	2,108	428	54,557	4	4.9	2,449,305	242,341	3,899
1914......	2,561	347	25,099	55	3.2	2,540,520	223,764	2,381
1915......	756	....	25,995	5,169	....	....	207,915	....

Year.	Iron.		Lead.		Manganese Ore.	Mineral Paints.	Oil Shale.	Phosphate of Lime.
	Ore.	Pig.	Ore.	Pig.				
1903....	13,935,748	4,573,202	26,993	20,278	831	14,377	2,041,851	71
1904....	13,994,670	4,596,803	26,796	20,155	8,896	16,307	2,370,391	59
1905....	14,824,183	(*f*)9,746,221	28,091	20,977	14,582	16,468	2,536,784	*Nil.*
1906....	15,748,412	(*f*)9,999,211	30,710	22,693	23,126	14,437	2,586,851	*Nil.*
1907....	15,983,310	(*f*)9,850,953	33,053	24,853	16,356	14,927	2,732,968	33
1908....	15,272,273	4,925,250	29,718	21,336	6,409	15,643	2,938,456	9
1909....	15,220,408	(*f*)9,818,916	30,221	22,823	2,812	16,575	3,014,678	4
1910....	15,470,392	5,055,595	28,992	21,867	5,554	16,782	3,180,520	Nil
1911....	15,768,511	5,101,089	24,186	18,279	5,067	14,819	3,166,838	....
1912....	8,552,343	4,525,830	25,729	19,473	4,237	14,179	3,235,942	....
1913....	16,263,950	5,224,607	24,656	18,462	5,480	15,387	3,333,048	....
1914....	15,115,375	4,865,858	26,422	19,684	3,494	14,701	3,323,144	....
1915....	8,004,753		21,036		4,716		3,047,632	....

Year.	Pyrite.	Salt.	Silica (Chert and Flint).	Silver. *Kg.*	Stone.			
					Igneous Rock.	Limestone. (*d*)	Sandstone.	Slate.
1903.......	9,794	1,917,274	74,355	5,440	5,512,605	12,419,120	5,496,312	540,143
1904.......	10,452	1,921,899	66,300	4,967	6,084,642	12,235,825	5,391,265	572,181
1905.......	12,381	1,920,149	71,808	5,212	6,052,210	12,701,808	5,729,799	523,892
1906.......	11,318	1,996,593	69,300	(*b*)	6,264,402	12,962,725	5,345,328	500,546
1907.......	10,358	2,016,409	54,523	4,780	5,765,262	12,709,288	5,092,246	450,651
1908.......	9,600	1,873,555	64,813	4,207	6,211,860	11,977,007	5,105,481	420,979
1909.......	8,964	1,851,999	53,063	4,421	6,384,144	12,000,790	4,673,839	408,639
1910.......	10,393	2,083,543	75,089	4,251	6,714,774	12,713,565	4,456,679	423,006
1911.......	10,276	2,116,115	72,726	3,684	6,629,417	12,378,725	4,109,828	431,948
1912.......	10,691	2,157,621	75,963	3,955	6,748,852	11,692,338	3,903,560	389,812
1913.......	11,611	2,285,221	76,105	4,439	7,216,801	12,953,008	4,043,591	376,935
1914.......	11,848	2,285,221	77,483	4,709	7,254,164	12,361,082	3,522,270	324,227
1915.......	10,711	2,104,489	....	....	....	....	....	....

Year.	Strontium Sulphate.	Tin.		Tungsten Ore.	Uranium Ore.	Zinc.	
		Ore, Dressed.	Block.			Ore.	Spelter.
1903...........	23,209	7,500	4,351	276	6	25,287	9,430
1904...........	18,460	6,849	4,198	164	*Nil.*	28,097	10,427
1905...........	14,523	7,316	4,540	174	105	24,025	9,023
1906...........	14,338	6,376	(*b*)	267	11	23,189	(*b*)
1907...........	10,917	7,192	4,478	327	72	20,402	7,222
1908...........	16,733	8,137	5,133	237	72	15,469	5,926
1909...........	14,267	8,422	5,282	382	6	10,061	5,828
1910...........	4,838	7,693	4,874	275	76	11,418	4,235
1911...........	5,963	7,870	4,950	270	68	17,935	6,196
1912...........	19,693	8,302	5,342	192	43	17,988	60,163
1913...........	18,732	8,494	5,376	185	96	18,073	5,920
1914...........	13,376	8,220	5,144	208	350	15,676	5,295
1915...........	....	6,525	....	334	83	12,254	....

(*a*) From *Mineral Statistics of the United Kingdom*. (*b*) Not reported. (*c*) Bog ore, which is mined in Ireland, is an ore of iron, used principally for purifying gas. (*d*) Does not include chalk. (*e*) Includes China clay, potters' clay, and fuller's earth. (*f*) Includes production from imported ore. (*h*) Includes shale.

MINERAL IMPORTS OF THE UNITED KINGDOM (*a*)

(In metric tons or dollars; £1 = $5)

Year.	Alkali.	Asphaltum.	Borax.	Coal, Coke, and Pat. Fuel.	Copper.			Iron and Steel.		
					Ore.	Regulus and Precipitate.	Wrought, Unwrought and Old.	Iron Ore.	Pig Iron.	Scrap.
1904...	(*c*)14,325	(*b*)	16,012	2,812	80,771	67,739	90,717	6,198,368	132,494	19,326
1905...	(*c*)16,593	(*b*)	11,552	49,277	94,198	70,235	71,294	7,172,171	128,183	23,569
1906...	(*c*)14,070	(*b*)	16,955	49,269	97,789	76,073	75,487	7,634,839	90,674	36,559
1907...	(*c*)15,579	(*b*)	17,551	19,136	105,409	73,101	89,312	7,764,589	104,950	27,404
1908(*i*)	(*c*)13,732	(*b*)	(*n*)19,424	3,904	111,897	71,120	124,226	6,154,733	69,930	24,653
1909...	(*c*)10,857	(*b*)	(*n*)16,349	6,419	(*l*)90,579	(*l*)66,337	(*l*)133,758	(*l*)6,429,996	(*l*)111,300	(*l*)33,475
1910...	(*c*) 8,996	(*o*)14,415	16,277	36,615	99,755	70,081	89,279	7,133,483	173,68	70,176
1911...	(*c*) 9,463	(*o*)20,866	20,621	30,672	87,986	65,914	101,059	6,448,462	178,167	51,002
1912...	8,812	(*b*)	21,091	194,866	99,802	52,393	96,499	6,708,443	223,586	64,195
1913...	9,140	(*b*)	23,837	24,429	95,837	39,762	108,728	7,566,276	220,320	124,854
1914...	10,583	....	20,493	45,315	72,766	43,252	152,974	5,799,918	227,099	112,405
1915...	8,757	....	21,672	3,843	38,766	39,011	183,393	6,306,547	202,500	115,150

Year.	Iron and Steel (*Continued*). Puddled and Wrought	Sheets and Plates.	Rails.	Strips, Wire, and Wire Rods.	Nails, Screws, Rivets, Bolts.	Steel Ingots, Blooms, Billets, etc.	Steel Bars, Shapes, Beams, Pillars.	Mnfrs. Unenumerated. (*h*)	Lead. Ore.	Lead. Pig and Sheet.
1903..	196,084	73,079	74,939	35,574	51,888	278,441	343,259	$9,007,990	18,923	232,939
1904..	109,289	69,552	40,438	38,214	50,649	531,069	219,510	8,630,380	8,748	250,452
1905..	110,576	69,831	34,439	60,318	55,331	613,612	148,995	8,783,895	(*i*) 27,649	233,214
1906..	111,062	83,747	11,900	61,288	57,071	493,805	149,363	7,824,405	(*i*) 30,795	211,577
1907..	83,145	57,280	19,33	56,110	51,863	332,442	90,327	3,731,275	(*i*) 13,609	207,970
1908(*i*)	85,270	56,652	31,393	109,313	54,251	437,238	231,859	3,034,895	23,861	241,320
1909..	(*l*) 95,553	(*l*) 68,067	(*l*) 22,430	(*l*) 132,543	(*l*) 59,197	(*l*) 392,008	(*l*) 264,909	2,819,365	(*b*)	(*l*) 210,982
1910..	(*l*) 98,859	88,245	16,074	163,681	58,977	361,401	349,662	3,239,715	(*b*)	222,450
1911..	119,583	115,349	36,588	173,764	62,314	512,841	500,643	(*p*) 3,654,825	(*b*)	217,134
1912 .	167,774	103,224	24,640	205,749	73,745	607,470	509,002	4,270,000	(*b*)	208,671
1913..	204,218	172,301	38,701	225,690	66,086	568,512	597,591	10,098,040	(*b*)	207,559
1914..	132,194	121,433	24,033	179,772	62,317	325,245	459,771	8,852,884	....	227,931
1915..	46,775	31,016	15,956	199,558	65,410	453,617	108,939	8,678,975	....	260,751

Year.	Manganese Ore.	Mica, Sheet.	Mica and Talc.	Paraffin.	Petroleum. *Liters.*	Phosphate Rock.	Platinum, Wrought and Unwrought. *Kg.*	Potassium Nitrate.	Pyrites of Iron and Copper.
1903.......	235,574	(*b*)	(*b*)	49,163	1,299,570,625	398,997	(*b*)	9,425	747,714
1904.......	208,458	(*b*)	(*b*)	42,882	1,373,488,176	425,978	(*b*)	12,277	754,722
1905.......	289,827	(*b*)	(*b*)	41,247	1,364,301,583	427,762	(*b*)	8,260	709,926
1906.......	314,016	(*b*)	(*b*)	44,673	1,130,667,737	450,058	(*b*)	10,125	771,473
1907.......	513,750	(*b*)	(*b*)	46,542	1,382,595,355	512,601	(*b*)	10,719	781,486
1908 (*i*)....	349,694	(*b*)	(*b*)	(*n*) 46,504	(*n*) 1,300,726,576	537,628	(*b*)	(*n*) 11,913	771,091
1909.......	335,813	(*b*)	(*b*)	(*n*) 53,289	(*n*) 1,355,562,599	459,058	(*b*)	(*n*) 10,704	(*l*) 803,725
1910.......	489,948	(*b*)	(*b*)	(*n*) 54,073	(*n*) 1,308,396,240	462,905	(*b*)	11,558	825,284
1911.......	364,676	(*b*)	(*b*)	51,456	1,661,100,144	501,332	(*b*)	11,376	863,583
1912.......	393,798	(*b*)	(*b*)	74,836	1,879,486,588	528,620	(*b*)	11,034	921,717
1913.......	611,227	(*b*)	(*b*)	57,974	(*g*) 488,106,963	548,000	(*b*)	12,092	794,740
1914.......	487,426	......	......	53,576	(*g*) 646,894,523	564,865	....	10,666	816,449
1915.......	383,613	......	......	93,677	(*g*) 595,158,694	380,883	....	14,060	918,468

Year.	Quicksilver.	Silver Ore. (*d*)	Sodium Nitrate.	Sulphur.	Tin. Ore.	Tin. Block, Ingot, Bars or Slabs.	Zinc. Ore.	Zinc. Spelter.	Zinc. Mnfrs.
1903........	1,187	$6,596,045	118,582	21,313	12,473	36,076	41,009	86,539	23, 18
1904........	1,130	8,271,480	122,454	17,629	15,734	39,932	54,438	90,088	22, 88
1905........	1,158	10,426,570	106,107	18,163	(*b*)	40,391	23,909	92,261	20,013
1906........	1,320	10,532,020	110,222	22,704	21,003	44,306	(*i*) 22,824	95,203	19,164
1907........	1,341	11,224,650	115,716	15,730	21,205	44,505	(*i*) 66,076	90,756	20,663
1908(*i*)......	1,483	10,743,400	(*n*) 148,056	(*n*) 19,580	25,414	48,496	61,661	91,548	38,717
1909........	(*m*) 1,469	10,409,800	(*n*) 91,650	21,211	(*m*) 24,471	(*l*) 42,393	(*b*)	104,217	19,280
1910........	1,517	9,311,665	128,528	20,496	26,490	47,028	(*b*)	123,061	18,460
1911........	1,584	8,420,954	130,549	21,269	29,300	46,643	(*b*)	117,077	19,417
1912........	1,607	7,523,692	125,664	22,109	29,112	43,850	(*b*)	139,461	20,673
1913........	1,543	5,718,552	143,275	18,518	35,169	46,443	(*b*)	147,421	19,081
1914........	1,283	4,324,576	174,775	22,162	32,938	41,644	....	117,660	12,690
1915........	1,381	3,446,485	134,360	36,247	45,494	39,544	....	75,762	8,170

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Classified as soda compounds since 1901. (*d*) Includes the value of silver in argentiferous ore and metal. (*f*) Not separately enumerated. (*g*) Gallons. (*h*) Prior to 1900, many manufactures were not reported separately. (*i*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Min. Journ.* (*n*) *Oil, Paint and Drug Reporter.* (*o*) From Trinidad. (*p*) There are besides, not here given, pipes, castings and forgings amounting to 51,000 tons.

MINERAL EXPORTS OF THE UNITED KINGDOM—DOMESTIC PRODUCTS (*a*)
(In metric tons or dollars; £1 = $5)

Year.	Bleaching Materials.	Cement.	Coal.	Coke.	Patent Fuel.	Supplied to Steamers.	Coal Products. (*c*)
1903	49,415	406,388	45,669,258	728,957	970,449	17,068,646	7,290,825
1904	35,289	390,736	46,995,636	779,060	1,257,589	17,465,954	6,879,400
1905	42,526	463,863	48,236,334	786,498	1,126,190	17,674,484	6,742,455
1906	45,510	668,461	56,489,367	828,266	1,399,244	18,887,656	7,226,790
1907	48,856	777,741	64,621,743	997,170	1,504,661	18,917,660	7,726,685
1908	39,120	607,950	63,551,057	1,212,184	1,463,557	19,786,734	(*n*) 7,711,360
1909(*k*)...	(*n*) 46,321	607,825	64,089,132	(*l*) 1,180,218	(*l*) 1,479,142	20,029,427	(*n*) 7,276,050
1910	(*n*) 51,188	747,627	(*l*) 63,081,948	979,526	1,494,397	(*l*) 19,839,123	(*n*) 8,398,405
1911	46,416	727,092	65,636,084	1,076,887	1,638,625	19,573,379	£2,517,355
1912.....	41,989	656,460	65,479,346	1,042,489	1,590,557	18,584,946	£2,981,159
1913	36,928	761,232	74,623,453	1,254,502	2,087,407	21,382,032	£2,279,790
1914	30,458	608,344	60,023,878	1,202,562	1,634,553	18,844,505	£2,283,062
1915	25,086	432,243	44,260,350	1,027,140	1,245,489	13,858,147	£2,554,008

Year.	Copper.				Iron.				
	Ingot.	Mixed or Yellow Metal.	Mfrs.	Sulphate.	Ore.	Pig.	Scrap.	Cast Iron and Mfrs.	Wrought Iron, Shapes and Mfrs.
1903 ...	23,723	14,425	16,975	54,307	4,534	1,082,426	143,929	62,249	217,139
1904 ...	14,791	16,704	18,467	71,367	6,706	823,909	166,010	49,004	173,233
1905 ...	21,232	9,959	22,128	55,219	14,664	997,601	151,619	49,193	186,340
1906 ...	19,778	7,149	16,195	43,670	13,415	1,670,753	180,547	54,876	203,521
1907 ...	25,652	7,994	16,676	46,049	15,538	1,978,350	162,295	43,218	215,159
1908(*k*)	14,869	15,546	19,796	(*m*) 72,429	4,478	1,317,330	135,115	48,336	174,539
1909 ...	12,465	(*m*) 11,381	17,248	(*m*) 45,547	(*l*)5,185	(*l*)1,026,517	(*l*) 165,183	(*l*) 44,406	(*l*) 171,698
1910 ...	11,898	(*m*) 15,970	12,551	43,391	(*l*)7,464	(*l*)1,062,444	(*l*) 150,507	(*l*) 57,148	(*q*)143,707
1911 ...	10,970	15,101	24,669	81,112	(*l*)6,352	1,222,622	147,759	(*l*) 70,618	140,312
1912 ...	12,993	11,108	19,327	85,497	6,241	1,284,220	127,610	68,676	144,747
1913 ...	15,165	14,711	22,317	76,950	5,278	1,142,917	117,645	82,816	139,593
1914 ...	7,390	13,420	18,367	69,015	13,742	793,703	90,037	73,339	151,062
1915 ...	6,764	3,923	14,076	66,297	1,697	621,810	52,031	47,647	121,826

Year.	Iron (*Continued*).								
	Rails.	Wire and Mfrs. of.	Plates and Sheets.	Galvanized Sheets.	Black Plates for Tinning.	Tinned Plates.	Steel Ingots, Billets, Blooms, etc.	Steel Shapes, Beams, and Pillars.	Total Iron and Steel, and Mfrs. of.
1903 ..	613,741	60,800	165,672	357,665	66,279	297,485	13,427	159,330	3,621,637
1904 ..	533,895	61,894	154,774	391,608	63,467	365,262	4,324	176,232	3,315,049
1905 ..	555,390	82,519	207,866	413,533	69,937	360,630	8,735	219,491	3,781,058
1906 ..	470,652	96,641	279,459	450,221	66,749	381,421	11,924	311,231	4,763,868
1907 ..	595,272	103.100	305,399	476,838	72,675	411,814	13,705	344,135	5,249,028
1908(*k*)	589,525	95,801	210,526	396,366	62,079	409,335	2,452	278,792	4,162,065
1909 ..	(*l*) 589,499	(*l*) 107,406	(*l*) 169,918	(*l*) 502,791	(*l*) 61,025	(*l*) 446,781	(*l*) 3,217	(*l*) 309,555	4,278,172
1910 ..	490,068	(*l*) 124,703	(*l*) 197,858	(*l*) 606,530	(*l*) 56,691	(*l*) 490,733	(*l*) 3,340	(*q*)230,850	4,661,647
1911 ..	381,320	(*l*)129,252	(*l*) 203,850	627,215	(*l*) 68,137	492,104	(*f*) 4,376	231,793	4,588,385
1912 ..	418,742	121,215	218,585	669,252	66,775	488,629	4,241	245,033	4,891,270
1913 ..	517,251	118,814	204,452	774,948	72,977	503,170	4,942	255,580	5,017,456
1914 ..	451,030	100,938	145,017	576,044	58,192	442,755	5,784	204,726	3,953,722
1915 ..	257,552	64,407	250,400	291,187	54,383	374,742	16,106	497,622	3,252,440

Year.	Lead, Pig and Mfrs.	Salt.	Sodium.				Tin, Block	Zinc.		
			Soda Ash.	Carbonate and Bicarbonate.	Hydrate.	Sulphate.		Ore.	Spelter.	Mfrs.
1903 ..	36,152	594,300	58,605	23,574	59,725	45,630	6,349	15,659	8,192	(*i*)
1904 ..	35,600	632,605	61,327	25,252	61,985	40,324	5,953	14,606	7,930	(*i*)
1905 ..	42,265	588,389	67,678	28,425	68,675	33,681	7,741	(*b*)	7,451	(*i*)
1906 ..	45,612	629,658	86,232	26,970	72,218	44,448	8,631	(*b*)	7,962	(*i*)
1907 ..	44,068	592,989	91,120	29,539	70,432	45,898	8,808	11,511	6,666	(*i*)
1908(*k*)	50,221	532,101	(*n*) 83,713	(*n*) 20,805	(*n*) 73,769	(*n*) 22,974	9,486	3,833	8,537	(*i*)
1909 ..	(*m*) 46,399	523,690	(*n*) 97,480	(*n*) 23,378	(*n*) 80,439	(*n*) 35,587	11,373	(*b*)	(*m*) 8,684	(*i*)
1910 ..	47,588	571,845	110,188	23,295	84,291	58,960	12,576	(*b*)	9,247	(*i*)
1911 ..	44,733	614,572	125,945	26,353	82,356	59,382	11,736	(*b*)	9,736	(*i*)
1912 ..	47,782	557,291	144,073	29,403	79,527	50,759	12,152	(*b*)	10,881	......
1913 ..	49,261	542,157	159,714	39,175	76,152	67,504	11,687	....	11,313	......
1914 ..	36,486	504,848	181,754	37,724	75,618	40,366	13,599	....	7,580	......
1915 ..	40,835	508,022	221,850	43,517	56,781	31,931	14,389	......	2,428	......

(*a*) From *Accounts Relating to Trade and Navigation of the United Kingdom.* (*b*) Not reported. (*c*) Including naphtha, paraffin, paraffin oil and petroleum. (*d*) Previous reports not available. (*e*) Includes puddled iron. (*f*) Includes railroad material of all kinds. (*g*) Includes all soda compounds; not separate; enumerated previous to 1901. (*h*) Included under soda ash. (*i*) Included under spelter. (*k*) From *Mines and Quarries.* (*l*) From *Iron and Coal Trades Review.* (*m*) *Mining Journal.* (*n*) From *Oil Paint and Drug Reporter.* (*q*) Bars only.

UNITED STATES

Of the following tables, the first records the imports of foreign mineral and metal products into the United States, whether dutiable or duty-free; the second shows the exports of materials produced in the United States; and the third reports the re-exports of products of foreign origin. These statistics are as reported by the Bureau of Statistics of the Department of Commerce and Labor, and special acknowledgment is due to the Chief of this Bureau, for furnishing the figures for many substances which are not reported in the Monthly Summary. The complete statement of production in the United States is given under the separate chapters.

IMPORTS (a)

Year.	Aluminium. Crude.				Ammonium Sulphate.			
	Lb.	Kg.	Value.	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.
1906	770,713	349,195	$154,292	$0.200	31,797,291	14,423	$894,663	$0.028
1907	872,474	395,754	181,352	0.208	70,440,992	31,960	1,828,236	0.026
1908	465,317	210,785	80.268	0.173	76,475,104	34,698	1,982,830	0.026
1909	5,109,843	2,317,784	745,963	0.145	85,829,334	38,932	2,114,694	0.024
1910	(o)12,271,277	5,567,730	1,844,830	0.151	184,686,534	83,795	4,668,820	0.025
1911	4,173,308	1,893,000	598,272	0.143	189,265,797	85,850	5,066,470	0.027
1912	22,759,937	10,326,650	3,092,889	0.136	119,085,120	54,049	3,447,225	0.029
1913	23,185,775	10,519,861	3,905,977	0.169	130,549,440	59,252	3,957,307	0.030
1914	16,241,340	7,369,029	2,729,383	0.168	166,031,040	75,356	4,475,603	0.027
1915	8,534,834	3,871,375	1,511,988	0.165	72,748,480	33,008	1,934,625	0.027

Year.	Antimony. (r)				Antimony Ore.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.
1906....	7,900,194	3,583	$1,417,816	$0.179	2,247,131	1,019	$128,347	$0,057
1907....	8,662,683	3,928	1,423,276	0,164	2,780,186	1,261	180,903	0.065
1908....	8,114,651	3,954	572,979	0.071	3,280,922	1,488	106,930	0.033
1909....	9,652,568	4,335	619,179	0.064	3,386,708	1,575	94,249	0.027
1910....	9,899,514	4,487	572,031	0.058	*Nil.*	....	....	....
1911....	10,957,844	4,970	573,564	0.052	*Nil.*	....	....	....
1912...	17,645,870	8,006	936,920	0.053	*Nil.*	....	....	....
1913....	15,333,492	6,957	878,773	0.057	49,803	221	1,739	0.035
1914....	13,070,381	5,930	737,233	0.056	1,986,082	901	54,408	0.027
1915....	17,484,030	7,933	3,633,420	0.206	3,374,012	1,531	351,540	0.104

Year.	Asbestos.			Asphaltum.			
	Crude, Value.	Mfd., Value.	Total Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906 ...	$536,500	....	....	97,274	98,830	$388,010	$3.93
1907 ...	1,104,109	$200,371	$1,304,480	127,902	129,948	518,074	4.05
1908 ...	1,068,342	147,548	.1,215,869	131,862	133,971	587,698	4.45
1909 ...	993,254	240,381	1,233,635	132,807	134,939	646,655	4.87
1910 ...	1,235,170	308,078	1,543,248	166,379	169,041	776,283	4.66
1911 ...	1,413,541	161,442	1,574,983	174,234	177,030	778,185	4.47
1912 ..	1,456,012	363,759	1,819,771	194,775	198,021	919,467	4.72
1913. ..	1,928,705	389,664	2,318,369	193,783	197,012	911,921	4.71
1914 ...	1,407,758	368,344	1,776,102	124,214	126,284	682,748	5.50
1915 ...	1,981,483	437,320	2,118,803	123,436	125,452	688,357	5.51

Year.	Arsenic. (b)				Barytes.				Bauxite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906....	7,639,507	3,464	$336,609	$0.044	4,293	4,362	$37,296	$8.69	17,809	18,094	$63,221	$3.55
1907....	9,922,870	4,500	553,440	0.056	28,350	28,804	174,225	6.15	25,065	25,466	93,208	3.72
1908....	9,592,881	4,558	417,137	0.056	n)12,196	12,390	58,822	4.83	21,679	22,033	87,823	4,05
1909....	7,183,644	3,259	272,493	0.038	n)13,091	13,301	54,707	4.19	18,989	18,689	83,956	4.49
1910....	8,257,474	3,745	251,716	0.031	n)16,960	17,226	48,457	2.86	14,038	14,258	65,743	4.68
1911....	5,404,263	2,451	159,626	0.030	20,860	21,195	58,726	2.82	43,222	43,916	164,301	3.80
1912....	6,758,946	3,066	246,815	0.037	26,665	27,093	79,315	2.97	26,214	26,635	95,431	3.64
1913....	6,688,216	3,034	285,537	0.043	36,875	37,490	99,564	2.97	21,456	21,814	85,746	3.99
1914....	4,079,372	1,851	165,266	0.040	25,598	26,025	77,265	3.02	24,844	25,258	96,500	3.88
1915....	3,573,624	1,621	154,517	0,043	3,404	3,460	15,613	4.59	3,421	3,477	17,500	5.12

Year.	Bismuth.				Chrome Ore.				Coal, Anthracite.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1906 .	254,733	115,000	$318,452	$1.25	43,441	44,136	$557,594	$12.84	32,357	32,875	$105,190	$3.25
1907 .	259,881	117,882	325,015	1.25	41,999	42,671	491,925	11.71	9,896	10,054	40,966	4.14
1908 .	164,793	73,002	257,397	1.56	27,876	28,320	345,960	12.40	16,483	16,747	73,777	4.47
1909 .	183,413	83,195	286,516	1.56	39,820	40,459	460,758	11.57	4,709	4,785	19,438	4.13
1910 .	198,174	89,916	332,674	1.67	38,579	39,196	415,768	10.77	8,196	8,327	42,234	5.14
1911 .	172,093	78,061	311,771	1.81	37,529	38,131	407,958	10.87	2,463	2,502	12,550	5.10
1912 .	182,839	82,935	316,440	1.73	53,929	54,828	499,818	9.27	1,670	1,698	8,329	4.99
1913 .	117,747	53,424	213,257	1.81	65,180	66,266	627,821	9.56	921	936	5,697	6.19
1914 .	90,505	41,064	165,248	1.83	74,686	75,931	655,306	8.77	19,347	19,669	37,998	1.96
1915 .	44,362	2,122	108,288	2.44	76,455	77,704	780,061	10.20	2,998	3,047	14,922	4.98

Year.	Coal, Bituminous.				Total Coal.		Coke.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906....	1,712,150	1,739,544	$4,129,555	$2.41	1,744,507	$4,234,745	114,703	116,538	$558,419	$4.87
1907....	2,116,122	2,149,980	5,398,167	2.55	2,126,018	5,439,133	132,536	134,656	594,137	4.48
1908....	1,487,816	1,511,621	4,059,786	2.73	1,504,299	4,133,563	129,591	131,624	603,964	4.65
1909....	1,257,629	1,277,814	3,597,991	2.56	1,262,338	3,617,429	170,671	173,410	735,253	4.31
1910....	1,991,943	2,023,914	5,381,062	2.69	2,000,270	5,423,296	156,417	158,920	625,619	4.00
1911....	1,238,808	1,258,691	3,611,518	2.92	1,241,271	3,624,068	69,515	70,631	254,938	3.67
1912....	1,608,350	1,635,156	4,509,636	2.80	1,610,020	4,517,965	110,347	112,186	488,691	4.43
1913....	1,413,857	1,437,421	3,856,811	2.73	1,414,778	3,862,508	93,507	95,065	442,087	4.73
1914....	1,375,316	1,398,238	3,889,821	2.80	1,394,663	3,927,819	120,777	122,790	555,548	4.60
1915....	1,521,237	1,546,085	4,398,425	2.96	1,524,235	4,413,347	47.520	48,296	222,382	4.68

Year.	Chloride of Lime.				Cement.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Barrels. (c)	Metric Tons.	Value.	Value per Bbl.
1906..........	105,221,371	47,718	$863,490	$0.008	2,205,712	400,115	$2,950,268	$1.33
1907..........	112,090,783	50,833	939,248	0.008	2,006,228	363,929	2,637,424	1.31
1908..........	74,602,059	33,848	621,713	0.008	839,246	152,313	1.189,560	1.42
1909..........	91,390,004	41,454	743,636	0.008	431,785	78,342	642,397	1.49
1910..........	101,029,345	45,839	797,260	0.008	292,314	53,053	396,428	1.36
1911..........	82,895,472	37,601	667,804	0.008	163,802	29,720	254,258	1.55
1912..........	74,235,256	33,682	597,002	0.008	65,064	11,808	93,583	1.44
1913..........	61,605,077	27,951	510,120	0.0083	77,333	14,035	134,187	1.74
1914..........	34,539,934	15,671	332,792	0.0096	115,270	20,920	193,155	1.68
1915..........	7,564,473	3,432	102,570	0.0135	40,097	72,772	57,149	1.43

Year.	Cobalt Oxide.				Copper, Ore and Matte.			
	Lb.	Kg.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906.......	41,084	18,652	$83,167	$2.02	208,702	212,041	$6,796,696	$32.56
1907.......	42,794	19,421	73,028	1.71	291,957	297,096	9,048,270	31.32
1908.......	1,550	701	3,095	2.00	288,022	292,630	6,978,513	24.20
1909.......	9,818	4,453	11,065	1.132	393,530	399,846	9,113,254	23.16
1910.......	6,124	2,778	4,806	0.785	453,747	461,007	9,182,161	20.23
1911.......	22,934	10,403	11.047	0.482	292,931	297,633	6,935,794	23.68
1912.......	31,848	14,446	15,132	0.475	499,549	507,875	12,696,532	25.42
1913.......	....	....	....	....	511,163	519,682	13,573,327	26.55
1914.......	227,886	103,397	220,593	0.97	417,222	424,176	12,172,138	29.17
1915.......	154,672	70,159	148,828	0.96	414,423	421,147	13,929,883	33.61

Year.	Copper, Ingots, Old, etc.				Cryolite.			
	Lb.	Metric. Tons.	Value.	Value. per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906.....	176,558,390	80,069	$30,416,578	$0.172	1,505	1,529	$29,683	$19.72
1907.....	192,901,267	87,523	38,658,754	0.200	1,438	1,461	28,920	20.10
1908.....	162,224,144	73,604	22,851,134	0.141	1,124	1,142	16,445	14.63
1909.....	240,713,721	109,186	30,529,425	0.127	1,278	1,299	18,427	14.42
1910.....	259,210,796	117,609	31,620,689	0.122	36	......	2,343	......
1911.....	265,940,760	120,630	31,540,827	0.119	2,007	2,039	47,093	23.46
1912.....	305,369,592	138,552	44,259,727	0.145	2,126	2,160	48,293	22.72
1913.....	300,068,849	136,147	44,328,574	0.148	2,559	2,602	52,557	20.54
1914.....	201,549,503	91,447	27,813,866	0.138	4,613	4,690	94,424	20.47
1915.....	201,367,008	91,360	30,617,535	0.152	3,940	4,004	82,750	21.00

Year.	Emery Grains.				Emery Rock.			
	Lb.	Metric. Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906....	4,655,168	2,113	$215,357	$0.043	13,840	14,061	$286,386	$20.69
1907....	4,282,228	1,942	186,156	0.043	11,235	11,415	211,184	18.80
1908....	1,735,366	788	89,702	0.052	8,084	8,213	146,105	18.09
1909....	2,696,960	1,224	132,264	0.049	9,836	9,993	186,930	19.00
1910....	1,189,664	535	53,709	0.045	16,770	16,321	344,421	20.54
1911....	712,134	323	35,384	0.050	10,232	10,396	176,890	17.29
1912....	791,667	359	32,876	0.042	15,793	16,052	284,585	18.01
1913....	2,496,372	1,133	114,806	0.046	17,122	17,377	342,809	20.03
1914....	761,674	346	30,017	0.039	12,662	12,873	255,554	20.10
1915....	569,639	258	22,655	0.040	8,313	8,449	180,594	21.72

Year.	Fuller's Earth.		Gold.		Iron Ore.			
	Long Tons.	Value.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906...	13,238	$108,696	$139,705,887	$15,873,493	1,060,390	1,007,356	$2,967,434	$2.80
1907...	14,648	122,221	130,605,413	12,792,659	1,229,168	1,248,835	3,937,483	3.20
1908...	10,963	92,413	38,346,267	11,930,026	776,898	789,326	2,224,248	2.86
1909...	11,406	101,151	30,648,147	13,438,819	1,694,957	1,722,161	4,579,078	2.70
1910...	13,775	132,545	47,212,754	12,009,764	2,591,031	2,632,617	7,832,225	3.02
1911...	16,272	143,594	46,623,766	10,821,418	1,811,732	1,840,810	5,412,636	2.99
1912...	17,062	145,337	55,789,906	10,758,866	2,104,576	2,139,652	6,499,690	3.09
1913...	16,632	146,001	51,618,628	12,086,204	2,594,770	2,638,016	8,336,819	3.21
1914...	22,302	195,083	46,311,059	11,076,682	1,350,588	1,373,891	4,483,832	3.32
1915...	17,349	152,493	438,302,822	13,651,768	1,341,281	1,363,189	4,181,645	3.12

Year.	Phosphates, Crude.				Pig Iron.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906....	23,281	23,653	$147,547	$6.34	379,828	385,905	$11,851,210	$31.20
1907....	25,876	26,290	163,944	6.34	489,475	497,305	13,418,982	27.42
1908....	26,734	27,161	175,365	6.56	92,202	93,677	2,886,339	31.35
1909....	11,903	12,094	97,277	8.18	176,442	179,265	5,112,045	28.97
1910....	19,384	19,688	235,040	12.12	237,233	241,029	6,549,938	27.61
1911....	16,153	16,412	157,394	9.74	148,459	150,842	4,380,334	29.50
1912....	28,821	29,284	231,255	8.02	129,325	131,481	4,770,730	36.89
1913....	....	....	....	....	156,450	159,058	6,557,095	41.91
1914....	15,178	15,431	136,526	9.00	139,683	141,218	4,694,186	33.60
1915....	5,359	5,446	50,606	9.44	89,836	91,303	4,108,180	45.73

Year.	Iron and Steel Scrap.			Bar Iron.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1906..........	19,091	19,397	$248,106	35,793	36,366	$1,590,592
1907..........	27,652	28,094	368,842	39,746	40,382	1,774,441
1908..........	5,090	5,171	61,981	19,671	19,980	837,585
1909..........	63,504	64,523	781,426	19,210	19,518	806,862
1910..........	72,764	73 928	928,002	38,231	38,783	1,565,999
1911..........	17,272	17,549	190,285	26,730	27,159	1,202,363
1912..........	23,612	24,006	256,710	26,112	26,547	1,151,853
1913..........	44,154	44,890	510,707	28,243	28,714	1,340,184
1914..........	34,849	35,430	277,818	15,015	16,688	625,365
1915..........	79,982	81,243	761,719	8,520	8,659	417,491

Year.	Rails.			Hoop, Band or Scroll.			Ingots, Blooms, Slabs, Billets, etc.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1906...	4,943	5,022	$137,104	10,231	10,395	$256,836	(*m*)21,337	21,678	$3,010,589
1907...	3,752	3,812	104,958	1,508	1,532	82,706	(*m*)19,334	19,643	3,004,178
1908...	1,719	1,752	53,128	1,110	1,127	75,920	11,212	11,391	1,437,514
1909...	1,542	1,567	36,963	(*f*)	(*f*)	(*f*)	19,289	19,599	2,695,630
1910...	(*f*)	(*f*)	(*f*)	(*f*)	(*f*)	(*f*)	46,578	47,323	4,075,036
1911...	(*f*)	(*f*)	(*f*)	(*f*)	(*f*)	(*f*)	29,205	29,687	2,772,614
1912...	3,780	3,843	101,544	(*f*)	(*f*)	(*f*)	18,702	19,014	2,941,481
1913...	10,408	10,581	216,272	(*f*)	(*f*)	(*f*)	26,765	27,202	3,505,463
1914...	22,571	22,947	610,037	648	659	23,702	44,653	40,845	2,943,047
1915...	78,525	79,808	2,088,532	....	....	....	14,998	15,243	1,941,601

Year.	Sheet, Plate and Taggers, Iron or Steel.			Tin Plates, Terne Plates and Taggers Tin.			Wire Rods.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1906...	3,231	3,283	$325,276	56,982	57,894	$3,883,225	17,799	18,084	876,270
1907...	3,749	3,809	367,140	57,773	58,697	4,462,522	17,076	17,349	851,571
1908...	2,628	2,669	377,549	58,492	59,426	3,651,576	11,208	11,387	543,170
1909...	4,711	4,787	536,841	62,593	63,598	3,782,952	10,544	10,613	531,652
1910...	6,107	6,205	461,632	67,086	68,159	4,502,862	20,374	20,700	1,024,831
1911...	2,454	2,495	275,498	14,089	14,324	1,081,864	15,483	15,980	731,291
1912...	3,299	3,354	363,141	2,053	2,087	229,891	15,069	15,320	726,205
1913...	2,893	2,941	381,593	20,680	21,025	1,478,635	16,098	16,366	802,401
1914...	4,310	4,382	514,080	15,411	15,668	1,049,297	6,954	7,070	373,615
1915...	1,416	1,444	218,954	2.350	2,389	196,328	5,317	5,403	331,724

Year.	Wire and Articles Made from.			Total Iron Imports. (e)	Lead in Ore and Base Bullion.		
	Long Tons.	Metric Tons.	Value.		Short Tons.	Metric Tons	Value.
1906 ...	6,610	6,716	$1.079,868	$34,827,132	72,371	65,640	$3,490,750
1907 ...	(f)	(f)	1,551,415	38,789,992	70,538	64,019	3,579,990
1908 ...	(f)	(f)	1,003,973	19,957,385	109,315	99,168	4,384,904
1909 ...	(f)	(f)	1,117,812	30,571,542	110,605	100,339	4,121,380
1910 ...	(f)	(f)	1,468,741	47,115,112	105,117	106,805	4,056,722
1911 ...	(f)	(f)	1,270,426	28,995,600	87,319	79,215	3,452,695
1912 ...	(f)	(f)	1,103,192	29,328,709	83,288	75,576	3,721,583
1913 ...	(f)	(f)	1,167,368	33,601,985	57,105	51,817	2,962,139
1914 ...	(f)	(f)	1,205,456	28,615,344	28,190	25,580	1,867,064
1915 ...	....	....	640,521	....	51,086	46,358	3,431,829

Year.	Lead in Pigs and Old.			Lead, Sheet, Pipe, Shot, etc.			Other Lead Mfrs.	Total Lead.
	Short Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.		
1906..........	11,763	0,669	$910,417	346,177	157	$17,250	$20,681	$4,401,167
1907..........	9,277	8,414	846,166	734,418	333	39,210	12,736	4,426,156
1908..........	2,759	2,504	182,503	42,376	19	2,026	46,486	4,567,407
1909..........	3,576	3,244	230,347	40,434	18	2,056	33,892	4,351,727
1910..........	3,491	3,166	202,376	(f)	....	....	7,073	4,259,098
1911..........	2,632	2,388	190,543	(f)	....	....	9,834	3,642,238
1912..........	272	247	19,917	31,284	14	2,305	7,328	3,748,828
1913..........	41	37	3,678	(f)	(f)	(f)	17,138	2,982,955
1914..........	148	134	10,082	(f)	(f)	(f)	83,672	1,960,818
1915..........	410	372	28,154	201,510	91	17,059	131,635	3,591,618

Year.	White Lead.				Litharge.				Red Lead.			
	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.	Lb.	Metric Tons.	Value.	Value per lb.
1906...	647,636	294	$41,233	$0.064	87,230	40	$3,737	$0.043	1,093,619	497	$50,741	$0.046
1907...	584,309	265	37,482	0.064	90,475	41	4,386	0.048	679,171	308	35,959	0.053
1908...	540,311	245	30,451	0.056	96,184	44	3,327	0.035	645,073	292	28,155	0.034
1909...	694,599	315	39,963	0.057	90,655	32	3,740	0.041	760,179	345	30,428	0.040
1910...	686,052	311	38,919	0.057	48,693	22	2,252	0.046	822,289	373	32,750	0.039
1911...	741,071	336	46,213	0.062	24,662	11	1,196	0.048	1,163,533	528	46,170	0.040
1912. .	687,705	312	46,494	0.068	32,443	15	1,550	0.048	757,908	344	33,854	0.045
1913...	671,839	305	48,266	0.072	34,023	15	1,750	0.051	99,562	45	4,903	0.049
1914...	707,774	321	50,089	0.072	33,651	15	1,805	0.054	6,014	3	260	0.044
1915...	339,157	154	24,608	0.073	20,650	9	1,422	0.069	1,968	1	132	0.067

Year.	Orange Mineral.				Magnesite.			
	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Metric Tons.	Value.	Value per L.T.
1906.....	770,342	350	$42,519	$0.055	80,711	82,002	$863,492	$10.70
1907.....	615,015	279	37,793	0.061	88,400	89,814	875,359	9.90
1908.....	485,407	220	26,645	0.055	75,442	76,648	736,763	9.80
1909.....	496,231	225	27,562	0.056	102.045	103,683	985,019	9.66
1910.....	600,461	269	32,199	0.053	152,078	154,511	1,542,800	10.14
1911.....	504,734	229	28,515	0.056	120,133	122,061	1,185,867	9.85
1912.....	334,551	152	20,914	0.063	123,801	125,788	1,369,665	11.06
1913.....	330,525	150	22,205	0.067	161,012	163,696	1,757,476	10.92
1914.....	240,388	109	16,388	0.068	120.688	122.699	1,427,772	11.83
1915.....	171,572	78	14,061	0.082	68,159	69,272	647,241	9.41

Year.	Manganese Ore.				Mica.	Nickel. (*h*)	Nickel Ore and Matte.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.			Long Tons.	Metric Tons.	Value.
1906.....	221,260	224,800	$1,696,043	$7.67	$1,042,608	$ 86,336	15,156	15,398	$1,816,631
1907.....	209,021	211,236	1,793,143	8.59	915,259	90,153	16,888	17,158	2,153,971
1908.....	178,023	181,054	1,350,223	7.59	264,755	101,398	16,322	16,582	2,396,217
1909.....	212,765	216,180	1,405,329	6.60	493,978	104,019	18,578	18,876	2,927,975
1910.....	242,348	246,226	1,711,131	7.06	721,541	139,772	28,519	28,975	4,085,076
1911.....	176,852	179,690	1,186,791	6.71	469,089	104,160	23,993	24,378	3,918,556
1912.....	300,661	305,672	1,769,184	5.84	745,399	120,511	33,101	33,653	5,638,456
1913.....	345,090	350,842	2,029,680	5.87	981,601	(*f*)	37,623	38,250	6,427,639
1914.....	283,294	288,016	2,024,120	5.88	204,850	(*f*)	29,564	30,056	4,956,448
1915.....	320,782	326,022	2,633,286	8.20	244,292	19,929	45,798	46,546	7,615,999

Year.	Oil, Mineral.			Platinum, Unmanufactured.				Platinum Mfrs.
	Gal.	Value.	Value per Gal.	Lb. Troy.	Kg.	Value.	Value per Lb. Troy.	
1906....	21,045,316	$1,061,076	$0.050	13,928	5,198	$3,601,021	$258.54	$187,639
1907....	20,505,197	1,037,728	0.051	7,515	2,805	2,509,926	333.99	175,651
1908....	9,289,376	393,050	0.042	4,155	1,551	1,096,615	263.92	134,119
1909....	3,862,445	198,540	0.051	9,904	3,696	2,557,574	258.30	410,997
1910....	24,323,829	1,438,609	0.059	10,009	3,736	3,320,699	331.77	1,717,584
1911....	69,019,304	2,406,581	0.035	2,868	1,070	1,278,293	445.71	3,587,998
1912....	309,765,930	6,033,231	0.019	3,692	1,378	1,716,630	464.96	2,777,853
1913....	731,360,523	12,997,011	0.018	4,283	1,599	1,978,770	462.01	3,065,489
1914....	724,446,909	11,500,730	0.016	2,676	999	1,154,955	431.60	1,818,668
1915....	763,705,698	10,563,628	0.014	4,644	2,107	2,077,536	447.35	334,472

Year.	Potassium Salts.											
	Chlorate.			Chloride.			Chromate and Bichromate.			Nitrate.		
	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.	Value per Lb.
		$	$		$	$		$	$		$	$
1906....	45,873	3,103	0.068	223,203,387	3,858,895	0.017	30,098	2,102	0.080	11,326,256	371,595	0.033
1907....	12,980	959	0.074	252,303,441	4,175,353	0.017	18,171	1,307	0.072	18,291,890	574,977	0.031
1908....	17,607	1,447	0.082	214,338,887	3,415,326	0.016	216,080	15,453	0.072	16,118,160	470,116	0.029
1909....	22,425	1,837	0.082	298,854,649	4,780,106	0.016	640,623	31,798	0.050	14,883,849	437,690	0.027
1910....	410,770	26,313	0.064	381,873,875	5,252,373	0.014	406,791	19,569	0.048	11,496,904	333,854	0.029
1911....	27,856	2,450	0.088	509,119,193	7,651,684	0.015	22,408	2,159	0 096	7,945,747	265,061	0.038
1912....	99,919	6,787	0.068	482,265,665	7,229,109	0.015	32,913	3,085	0.094	7,315,531	216,492	0.030
1913....	1,191,461	64,468	0.054	478,826,857	7,120,055	0.015	18,629	1,819	0.097	9,876,910	262,575	0.027
1914.. .	27,406	2,235	0.083	371,520,195	5,745,385	0.015	31,858	2,375	0.075	2,229,856	74,743	0.034
1915....	16,001	3,666	0.229	129,346,560	2,297,149	0.018	32,942	2,902	0.088	127,270	28,095	0.022

Year	Potassium Salts, All Other. (*s*)		Precious Stones.			Pyrite. (*i*)			
	Lb.	Value.	Uncut.	Cut, not Set.	Jewelry.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906.	30,302,735	$763,513	$11,937,542	$32,201,949	$988,766	597,347	606,903	$2,138,746	$3.58
1907.	91,299,496	2,220,685	8,740,278	23,706,975	1,069,373	256,479	666,981	2,637,485	4.01
1908.	69,382,278	1,721,626	2,367,189	11,660,442	720,502	668,115	678,804	2,624,339	3.93
1909.	100,180,417	2,445,526	9,230,287	34,340,269	1,267,457	692,385	703,498	2,428,638	3.51
1910.	116,820,873	2,777,396	9,426,647	32,424,471	1,907,148	806,590	819,495	2,773,627	3.46
1911.	155,140,643	3,909,361	9,963,393	30,224,826	1,470,167	1,001,944	1,018,025	3,788,632	3.78
1912.	131,049.932	3,185,098	9,979,582	26,218,261	989,288	964,478	980,553	3,860,738	3.88
1913.	124,519,551	3,253,245	12,630,037	27,626,937	998,723	848,674	862,819	3,611,136	4.00
1914.	....	....	3,008,823	13,652,861	775,364	977,372	993,662	4,706,383	4.82
1915.	41,109,008	1,461,637	7,124,316	14,161,769	....	974,616	990,531	4,817,977	4.95

Year.	Salt.				Silver.		Sodium Nitrate.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	In Coin and Bullion.	In Ore.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906..	170,505	154,648	$502,583	$2.95	$20,402,738	$23,825,103	372,222	378,178	$14,115,206	$37.92
1907..	153,435	139,166	452,227	2.95	17,652,679	28,259,681	364,610	370,444	14,844,675	40.71
1908..	156,608	142,043	440,484	2.81	14,169,524	28,054,606	310,713	315,684	11,385,393	36.68
1909..	158,487	143,777	447,983	2.83	15,728,756	30,458,946	428,429	435,569	13,608,195	31.43
1910..	142,549	129,320	388,015	2.72	15,913,668	29,964,500	529,172	605,938	16,601,328	31.37
1911..	137,759	124,974	378,083	2.74	16,351,154	27,395,417	544,878	553,623	16,814,256	30.86
1912..	136,391	123,762	361,664	2.65	24,053,983	24,347,103	486,352	494,458	16,554,104	34.04
1913..	150,602	136,609	416,375	2.77	19,979,971	15,887,848	625,862	636,293	21,630,811	34.56
1914..	130,752	118,649	385,752	2.95	18,941,980	7,017,207	541,715	552,777	15,228,671	28.01
1915..	123,576	112,138	366,475	2.97	26,375,801	8,108,163	772,190	784,803	22,959,997	29.73

Year.	Sodium Hydroxide (Caustic).			Soda Ash and Carbonate.			All other Sodium Salts.	
	Lb.	Value.	Value. per Lb.	Lb.	Value.	Value per Lb.	Lb.	Value.
1906..	1,209,053	$35,262	$0.022	6,800,288	$71,013	$0.010	....	....
1907..	1,297,070	37,894	0.029	6,198,136	66,521	0.011	8,481,979	$258,262
1908..	874,813	26,079	0.029	3,515,933	38,372	0.011	....	296,777
1909..	942,982	29,771	0.032	153,928	3,543	0.023	13,805,869	350,396
1910..	2,973,522	70,901	0.027	314,396	4,269	0.014	35,895,668	406,643
1911..	990,562	34,281	0.035	3,214,129	36,252	0.011	22,202,439	303,934
1912..	884,204	29,461	0.033	3,393,354	39,912	0.012	7,332,392	232,808
1913..	696,158	25,888	0.037	2,962,180	35,872	0.012	7,518,125	263,162
1914..	535,883	21,607	0.040	3,130,366	51,869	0.017	....	....
1915..	244,806	15,058	0.062	838,609	13,369	0.016	....	....

Year.	Sulphur.									
	Crude.				Flowers.			Refined.		
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1906..	72,404	73,562	$1,282,873	$17.72	1,100	1,118	$29,565	709	720	$17,928
1907..	20,399	20,725	355,944	17.45	1,458	1,481	41,216	606	616	14,589
1908..	20,118	20,441	318,577	15.83	793	804	22,562	692	700	17,227
1909..	26,914	27,346	458,954	17.05	770	782	23,084	966	982	26,021
1910..	28,647	29,105	495,988	17.31	915	930	30,180	990	1,004	25,869
1911..	24,250	24,639	436,725	18.01	3,891	3,953	83,491	986	1,002	24,906
1912..	26,885	27,333	494,778	18.40	1,310	1,331	39,126	1,665	1,692	40,933
1913..	14,636	14,880	278,056	19.00	5,899	5,997	115,574	1,233	1,254	29,091
1914..	22,810	23,190	409,537	18.39	621	631	17,214	1,800	1,830	47,568
1915..	24,647	25,050	405,990	16.43	647	658	23,046	988	1,004	30,335

Year.	Talc.				Tin.			
	Short Tons.	Metric Tons.	Value.	Value per Sh. T.	Lb.	Metric Tons.	Value.	Value per Lb.
1906...	5,643	5,118	$67,818	$12.02	101,027,188	45,816	$37,446,508	$0.371
1907...	10,060	10,221	126,391	12.56	82,548,838	37,436	32,075,091	0.389
1908...	7,429	6,738	97,296	13.08	82,503,190	37,433	23,932,560	0.290
1909...	8,377	7,599	102,964	12.29	95,350,020	43,250	27,559,937	0.289
1910...	8,378	7,560	106,451	12.72	105,137,740	47,703	33,921,449	0.322
1911...	7,113	6,453	88,050	12.38	106,936,872	48,506	43,390,639	0.406
1912...	10,817	9,813	121,541	11.24	116,003,385	52,633	50,371,102	0.434
1913...	14,004	12,702	143,500	10.25	104,282,230	47,315	46,900,314	0.450
1914...	17,869	16,210	202,415	11,33	95,049,612	43,126	32,861,188	0.346
1915...	18,069	16,396	199,840	11.06	115,636,332	52,465	38,736,909	0.336

Year.	Zinc.								
	Blocks, Pigs and Old.				Oxide. (j)		Sulphide.		Mfrs.
	Lb.	Metric Tons.	Value.	Value. per Lb.	Lb.	Value.	Lb.	Value.	Value.
1906	4,407,481	1,999	$253,310	0.057	4,494,014	$288,065	1,286,469	$40,112	$17,385
1907	3,555,890	1,613	210,322	0.059	5,311,318	323,551	1,570,073	51,435	16,282
1908	1,762,627	799	85,885	0.049	4,635,101	262,876	1,048,109	46,733	7,474
1909	19,340,029	8,772	826,588	0.043	6,654,352	397,084	1,263,316	44,873	19,176
1910	6,904,389	3,133	289,689	0.042	6,470,097	391,670	3,726,135	99,954	27,475
1911	3,275,340	1,486	170,634	0.052	5,561,016	357,466	6,355,312	166,199	124,983
1912	22,229,831	10,086	1,280,426	0.058	5,875,057	386,153	5,904,475	153,303	293,089
1913	12,199,267	5,535	660,706	0.054	6,865,094	433,886	5,066,535	152,980	62,256
1914	1,759,579	798	71,165	0.040	5,258,108	302,838	9,072,567	277,862	31,724
1915	1,808,964	821	131,468	0.072	1,764,887	154,149	4,251,772	144,567	15,753

(a) From Summary of Commerce and Finance of the United States. (b) Includes arsenic sulphide. (c) Barrels of 400 lb. (e) Not including iron ore. (f) Not reported. (h) Includes nickel oxide, alloys in which nickel is the principal constituent, and manufactures of nickel. (i) Containing more than 25 per cent. sulphur. (j) Includes white pigments containing zinc but not lead, dry and in oil. (m) Includes bars of steel and steel forms not elsewhere specified. The high value is due to the value of "high-speed" steel. (n) Crude. (o) Crude, scrap and alloys in which aluminum is chief component. (r) Antimony contents of ores, regulus and metal. (s) Not kainit.

EXPORTS OF DOMESTIC PRODUCTS (a)

Year.	Aluminium and Mfrs. of.	Asbestos and Mfrs. of.	Cement.			
			Bbl. (i)	Metric Tons.	Value.	Value per Bbl.
1906	$364,251	$259,760	583,299	105,811	$944,886	$1.62
1907	304,938	200,371	900,550	163,360	1,450,841	1.61
1908	330,092	296,890	846,785	153,638	1,249,229	1.47
1909	567,375	322,523	1,056,922	191,764	1,417,534	1.34
1910	949,215	348,716	2,475,957	449,314	3,477,981	1.40
1911	1,158,603	448,395	3,135,409	568,886	4,632,215	1.48
1912	1,347,621	601,701	4,215,532	765,069	6,160,341	1.46
1913	966,094	754,102	2,964,358	538,041	4,270,666	1.44
1914	1,546,510	513,037	2,140,497	388,475	3,088,809	1.44
1915	3,682,117	764,050	2,564,713	232,733	3,361,451	1.32

Year	Coal.									
	Anthracite.				Bituminous.				Coke.	
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Value.
1906	2,216,969	2,252,441	$10,896,200	$4.91	7,704,850	7,828,128	$19,787,459	$2.57	765,190	$2,753,550
1907	2,698,072	2,741,241	13,217,985	4.90	(m)10,454,677	10,621,950	(m)26,982,111	2.54	874,689	3,206,791
1908	2,752,358	2,796,394	13,524,595	4.92	(m) 9,100,819	9,246,431	(m)23,361,914	2.53	620,923	2,161,032
1909	2,842,714	2,888,340	14,141,468	4.97	(m) 9,693,843	9,849,429	(m)24,300,050	2.51	895,461	3,232,673
1910	3,021,627	3,070,124	14,785,387	4.89	(m)10,784,239	10,957,326	(m)26,685,405	2.47	879,073	3,053,293
1911	3,553,999	3,611,041	18,093,285	5.09	(m)13,878,754	14,101,508	(m)34,499,989	2.49	914,042	3,215,490
1912	3,688,789	3,750,268	19,425,263	5.27	(m)14,459,978	14,700,978	(m)36,817,633	2.55	814,800	3,002,742
1913	4,154,386	4,224,625	21,959,850	5.29	(m)17,986,757	18,286,536	(m)45,449,664	2.53	881,603	3,309,930
1914	3,830,244	3,894,081	20,211,072	5.28	(m)13,801,850	14,031,881	(m)34,104,903	2.47	592,487	2,233,686
1915	3,542,971	3,600,842	18,433,217	5.20	(m)16,762,283	12,040,614	(m)42,813,362	2.55	799,444	3,092,515

Year.	Copper.									
	In Ore and Matte.				Ingots, Bars, Plates and Old.				Mfrs.	Total, Except Ore.
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Lb.	Metric Tons.	Value.	Value per Lb.	Value.	
1906	47,619	48,380	$1,760,140	$36.96	454,752,018	206,239	$84,728,400	$0.186	$4,284,611	$89,013,011
1907	99,141	100,727	2,452,562	24.74	508,929,401	230,799	94,912,185	0.186	5,888,170	100,800,355
1908	63,149	64,158	1,254,172	19.87	661,876,127	300,302	87,393,200	0.132	3,162,303	90,555,503
1909	59,880	60,841	1,335,316	22.29	682,846,726	309,734	89,367,455	0.131	3,217,185	92,584,640
1910	43,784	44,585	1,049,086	23.96	695,107,043	315,384	88,949,799	0.128	5,132,287	94,082,086
1911	57,915	58,844	2,352,080	40.61	786,553,208	356,778	98,168,182	0.122	5,159,664	103,327,346
1912	66,171	67,274	3,203,220	48.41	775,000,658	351,634	123,007,884	0.159	3,762,283	126,770,167
1913	65,684	66,779	2,973,997	45.28	926,241,092	420,255	143,353,624	0.155	1,555,493	144,909,117
1914	43,529	44,254	1,606,855	36.91	840,080,922	381,162	116,026,290	0.138	1,162,060	117,188,350
1915	10,997	11,177	107,207	9.76	681,953,301	309,416	117,250,855	0.172	7,895,434	125,136,289

Year.	Gold.		Iron.							
			Ore.				Pig.			
	In Coin and Bullion. (*c*)	In Ore. (*d*)	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906	$46,068,451	$640,707	265,240	269,484	$771,831	$2.91	83,317	84,650	$1,506,774	$18.08
1907	54,869,688	345,993	278,208	282,659	763,422	2.74	73,703	74,879	1,508,938	20.43
1908	80,778,091	437,365	309,099	314,043	1,012,924	3.29	46,696	47,441	789,318	16.92
1909	132,349,610	540,211	455,934	463,251	1,365,325	2.99	61,989	62,994	1,030,267	16.66
1910	54,968,487	470,062	644,875	655,193	2,074,164	3.22	127,385	129,423	2,113,036	16.51
1911	34,488,840	499,265	768,386	780,719	2,653,448	3.45	120,799	122,738	1,874,401	15.52
1912	43,921,951	470,333	1,195,742	1,215,671	3,537,289	2.96	272,676	277,221	3,832,765	13.84
1913	88,331,790	602,781	1,042,151	1,059,520	3,513,419	3.37	277,648	282,275	4,026,306	14.50
1914	220,409,005	285,038	551,618	560,812	1,794,193	3.20	114,423	116,330	1,638,102	14.32
1915	18,902,237	419,330	708,641	720,216	2,181,629	3.08	224,499	228,121	3,666,993	16.33

Year.	Iron, Bar.				Iron, Band, Hoop and Scroll.			Billets, Ingots and Blooms.			
	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906......	56,024	56,920	$2,575,905	$45.98	5,405	5,491	$242,776	192,616	195,698	$4,094,659	$21.26
1907......	24,190	24,577	1,092,631	45.17	8,587	8,724	395,758	79,991	81,271	2,013,319	25.17
1908......	8,224	8,355	362,909	44.12	4,334	4,402	223,073	112,177	113,390	2,674,524	23.84
1909......	13,536	13,755	538,436	39.77	3,856	3,918	200,379	104,862	106,545	2,401,091	22.90
1910......	18,045	18,234	726,300	40.25	(*n*)	(*n*)	(*n*)	58,230	59,162	1,274,732	21.89
1911......	17,683	17,967	653,320	36.94	3,731	3,791	163,853	234,267	238,027	5,150,518	21.99
1912......	21,926	22,291	841,824	38.39	12,557	12,766	539,354	294,818	299,732	6,615,131	22.44
1913......	16,615	16,892	768,501	46.25	16,841	17,122	767,631	91,847	93,378	2,200,248	23.96
1914......	5,226	5,313	203,835	39.00	9,954	10,120	457,451	50,496	51,338	1,103,702	21.86
1915......	39,726	40,375	1,471,466	37.04	29,326	29,805	1,433,604	560,728	569,887	14,175,012	25.26

Year.	Iron, Nails and Spikes, Cut.				Iron, Nails and Spikes, All Other.				Iron, Plates and Sheets.		
	Lb.	Metric Tons.	Value	Value per Lb.	Lb.	Metric Tons.	Value.	Value per Lb.	Long Tons.	Met. Tons.	Value.
1906	16,951,893	7,688	$340,526	$0.020	116,310,428	52,747	$2,731,021	$0.024	17,054	17,327	$1,139,526
1907	15,521,208	7,042	354,802	0.023	111,670,147	50,642	3,014,863	0.027	40,651	41,301	2,902,025
1908	15,721,898	7,133	364,202	0.023	71,427,124	32,407	1,813,784	0.025	44,100	44,805	2,985,538
1909	22,256,458	10,095	456,635	0.021	85,387,006	38,731	1,993,142	0.023	75,305	76,513	4,706,592
1910	18,208,116	8,261	361,838	0.020	118,881,375	53,939	2,693,753	0.023	102,534	104,175	6,412,458
1911	25,585,379	11,605	470,515	0.018	148,875,384	67,529	3,279,105	0.022	134,497	137,113	8,353,089
1912	20,856,790	9,463	359,962	0.017	186,646,470	84,685	3,976,571	0.021	193,719	196,948	11,844,767
1913	8,488,503	3,851	165,068	0.019	132,014,432	59,898	3,031,967	0.023	98,978	100,628	6,568,413
1914	7,667,552	3,479	142,285	0.019	103,535,214	46,953	2,264,031	0.022	48,818	48,018	3,128,184
1915	9,444,124	4,285	189,787	0.020	255,663,350	11,000	6,046,662	0.024	101,487	103,145	6,602,866

Year.	Steel, Sheets and Plates.			Iron Rails.				Steel Rails.			
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906 ..	93,601	95,099	$4,081,915	*Nil.*	....	....	....	328,036	333,285	$8,903,411	$27.14
1907 ..	82,045	83,358	4,262,582	*Nil.*	....	....	....	338,906	344,328	10,411,072	30.72
1908 ..	60,893	61,865	3,422,031	*Nil.*	....	....	....	196,510	199,654	6,021,549	30.62
1909 ..	104,742	106,423	4,627,614	*Nil.*	....	....	....	299,540	304,533	8,519,793	28.44
1910 ..	171,982	174,734	7,514,832	*Nil.*	....	....	....	353,180	358,831	10,162,522	28.77
1911 ..	237,428	241,239	9,800,215	*Nil.*	....	....	....	420,874	427,629	12,229,045	29.05
1912 .	352,802	358,682	14,508,622	*Nil.*	....	....	....	446,473	453,914	13,053,774	29.24
1913 ..	364,448	370,522	14,472.711	*Nil.*	....	....	....	460,553	468,229	13,979,549	30.35
1914 ..	232,078	235,946	9,308,312	*Nil.*	....	....	....	174,680	177,591	5,103,918	29.22
1915 ..	361,455	367,359	11,764,484	*Nil.*	....	....	....	391,491	397,886	12,098,287	30.90

Year.	Structural Iron and Steel.				Wire.				Steel Wire Rods.			
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Long Tons.	Metric Tons.	Value.	Value per L. T.	Long Tons.	Metric Tons.	Value.	Value per L. T.
1906 .	112,555	114,356	$6,140,861	$54.56	174,014	176,798	$8,770,042	$50.40	5,896	5,990	$221,679	37.60
1907 .	138,442	140,657	7,784,618	56.23	161,228	163,808	9,164,829	56.84	10,653	10,823	465,757	43.72
1908 .	116,878	118,746	6,289,610	53.80	136,167	138,344	7,270,794	53.35	7,412	7,530	277,694	37.39
1909 .	90,830	92,288	4,488,197	49.42	149,341	151,738	7,836,564	52.49	20,142	20,465	635,409	31.56
1910 .	146,721	149,069	7,127,673	48.58	171,928	174,679	9,198,005	53.49	22,869	23,235	714,553	31.25
1911 .	223,493	227,080	10,270,977	45.96	229,762	233,452	11,637,596	50.65	22,641	23,003	659,066	29.10
1912 .	288,164	292,967	12,694,804	44.05	244,711	248,790	11,536,442	47.14	64,978	66,061	1,898,986	29.22
1913 .	403,264	409,985	17,790,744	44.12	190,284	193,455	9,237,541	48.55	61,637	62,664	1,815,922	29.46
1914 .	182,395	185,435	6,961,636	38.17	180,842	183,856	8,568,589	47.38	61,856	62,887	1,810,389	29.27
1915 .	232,937	236,742	8,959,233	38.46	473,588	481,324	25,830,628	54.54	120,370	122,432	4,713,109	39.14

Year.	Lead and Mfrs. of.	Nickel. (*e*)	Petroleum products. (In Thousands of Units.)*								
			Crude.			Naphtha.			Illuminating Oil.		
			M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.
1906...	$600,057	$3,493,643	148,045	$7,731	$0.052	27,545	$2,488	$0.090	878,284	$54,858	$0.063
1907...	686,096	2,845,663	126,306	6,334	0.050	34,625	3,676	0.106	905,924	59,635	0.066
1908...	599,640	3,297,988	149,190	6,520	0.044	43,887	4,543	0.103	1,129,005	75,988	0.067
1909...	509,542	4,101,976	186,305	6,568	0.035	68,759	5,800	0.084	1,046,401	67,814	0.065
1910...	614,158	4,704,088	180,111	5,404	0.029	100,695	8,407	0.083	940,247	55,642	0.059
1911...	680,419	8,283,777	201,843	6,165	0.030	137,295	11,483	0.084	1,112,295	61,055	0.055
1912...	651,459	8,515,332	188,711	6,770	0.036	186,000	20,459	0.110	1,026,138	62,084	0.061
1913...	738,135	9,686,794	194,570	8,448	0.043	188,043	28,092	0.149	1,119,441	72,042	0.064
1914...	5,519,908	9,455,528	124,736	4,959	0.040	209,693	25,288	0.121	1,010,449	64,113	0.063
1915...	11,758,046	10,038,514	158,263	4,283	0.027	282,331	33,926	0.120	836,999	49,947	0.059

Year.	Petroleum Products. (In Thousands of Units.)*									
	Lubricating Oil.			Residue, Etc. (*g*)			Paraffin.			
	M Gals.	M Value.	Value per Gal.	M Gals.	M Value.	Value per Gal.	M Lb.	M Metric Tons.	M Value.	Value per Lb.
1906 ...	151,269	$18,690	$0.124	64,645	$1,971	$0.030	173,504	$72.9	$8,463	$0.049
1907 ...	152,029	19,210	0.126	75,775	2,528	0.033	207,504	94.1	10,209	0.049
1908 ...	147,769	18,971	0.128	77,552	2,793	0.036	141,667	64.2	6,923	0.049
1909 ...	161,640	20,076	0.124	107,999	3,640	0.034	181,328	82.6	7,609	0.042
1910 ...	163,832	20,291	0.125	117,605	3,732	0.032	199,913	90.7	7,329	0.037
1911 ...	183,320	23,337	0.127	133,979	3,882	0.029	214,018	97.1	7,048	0.033
1912 ...	216,393	28,297	0.131	266,237	6,599	0.025	294,591	133.7	9,603	0.033
1913 ...	207,639	29,609	0.143	426,872	11,126	0.026	236,046	107.1	8,177	0.035
1914 ...	191,648	26,316	0.137	703,508	19,224	0.027	188,823	85.7	6,435	0.034
1915 ...	239,719	32,442	0.135	812,263	22,375	0.028	386,863	175.5	12,533	0.032

* For convenience in tabulating, the quantities of all petroleum products and their gross values have been divided by 1000.

Year.	Crude Phosphates.				Quicksilver.			Silver.	
	Long Tons.	Metric Tons.	Value.	Value per L.T.	Lb.	Metric Tons.	Value.	In Coin and Bullion (*c*)	In Ore (*d*)
1906....	904,214	918,681	$7,373,945	$8.16	484,151	219	$243,914	$57,012,104	$266,674
1907....	1,018,212	1,034,503	8,387,176	8.24	384,913	174	192,094	61,202,024	423,842
1908....	1,196,175	1,215,374	9,371,649	7.83	224,692	102	124,960	51,554,414	283,257
1909....	1,020,556	1,036,936	7,644,368	7.49	510,241	231	266,243	56,876,292	716,017
1910....	1,083,037	1,100,366	8,234,276	7.63	144,237	65	91,077	53,298,048	346,735
1911....	1,246,577	1,266,585	9,235,388	7.41	21,841	10	13,995	59,756,121	129,909
1912 . . .	1,206,520	1,226,629	8,996,456	7.46	23,283	11	13,360	66,846,486	137,752
1913....	1,366,508	1,389,283	9,996,580	7.32	85,521	39	43,574	59,509,520	154,769
1914....	964,114	980,183	6,771,652	7.02	108,426	49	70,753	47,767,578	76,084
1915....	253,549	257,690	1,605,639	6.33	252,852	115	225,509	47,403,607	63,628

Year.	Zinc Ore.				Zinc, Pigs, Bars, Plates and Sheet.			
	Long. Tons.	Metric Tons.	Value.	Value Per L.T.	Lb.	Metric Tons.	Value.	Value. per Lb.
1906	24,750	25,146	$733,300	$29.63	9,340,455	4,236	$583,526	$0.062
1907	18,171	18,462	579,490	31.89	1,126,753	511	75,194	0.067
1908	23,311	23,683	877,745	37.61	5,280,344	2,396	250,254	0.047
1909	11,121	11,299	412,300	37.01	5,131,360	2,328	263,010	0.051
1910	17,599	17,881	649,425	36.90	7,979,457	3,620	426,500	0.053
1911	16,322	16,584	642,884	39.39	13,744,212	6,234	810,099	0.059
1912	20,847	21,194	823,997	39.53	13,268,186	6,020	864,292	0.065
1913	15,815	16,079	631,991	40.00	15,565,324	7,062	955,667	0.061
1914	9,920	10,085	388,464	39.06	129,694,022	58,804	8,540,668	0.066
1915	743	755	35,276	47.48	128,735,815	58,410	11,627,295	0.090

Year.	Zinc Oxide.			
	Lb.	Metric Tons.	Value.	Value per Lb.
1906	31,156,616	14,129	$1,149,297	$0.037
1907	26,512,920	12,023	1,069,924	0.040
1908	24,016,254	10,893	845,070	0.035
1909	26,691,347	13,468	1,026,377	0.035
1910	26,333,993	11,949	943,968	0.036
1911	29,236,779	13,262	1,051,311	0.036
1912	34,128,163	15 484	1,247,702	0.037
1913	28,932,953	13,127	1,136,257	0.039
1914	31,183,369	14,148	1,408,525	0.045
1915	39,960,899	18,131	2,066,992	0.052

RE-EXPORTS OF FOREIGN PRODUCTS (*a*)

Year.	Antimony.			Antimony Ore.			Asphaltum, Crude.		
	Lb.	Metric Tons.	Value.	Short Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1906	24,892	11.2	$4,939	*Nil.*	......	......	1,765	1,793	$22,324
1907	47,999	21.8	9,064	6	5	$273	8,288	8,421	31,749
1908	1,763	0.8	125	4.8	4.3	663	4,262	4,290	21,419
1909	6,648	3.0	475	0.25	0.23	56	6,867	6,977	48,375
1910	339,685	154.1	20,392	*Nil.*	......	......	5,830	5,948	29,942
1911	160,844	73.0	9,737	*Nil.*	......	......	3,402	3,457	48,552
1912	(*o*)50,684	23.0	2,766	*Nil.*	......	......	2,589	2,632	62,276
1913	63.620	29.0	4,365	0.18	0.16	22	1,282	1,303	25,954
1914	1,600,979	7.27	211,742	....	......	......	21	21	387
1915	3,146,135	14.27	786,766	....	......	......	237	241	6,392

Year.	Cement.			Chemicals.					
				Salts of Potassium. (*f*)			Chloride of Lime.		
	Bbl. (*i*)	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1906	16,216	2,941	$19,487	2,264,175	1,027,935	$77,043	*Nil.*	....	......
1907	20,697	3,754	30,435	2,675,248	1,285,892	75,470	*Nil.*	....	......
1908	9,552	1,734	11,455	1,046,689	570,445	34,505	121,511	55,116	$912
1909	4,198	762	6,312	2,332,386	1,058,251	66,352	13,964	6,334	292
1910	17,914	3,251	24,878	2,187,787	922,645	60,648	496	225	6
1911	8,529	1,547	14,095	2,731,792	1,239,133	67,297	17,804	8,076	241
1912	4,356	791	8,419	4,932,143	2,237,814	103,425	400	181	8
1913	2,553	460	4,075	8,660,837	3,929,599	162,467	13,260	6,016	333
1914	719	130	1,038	8,760,640	3,974,882	204,423	15,990	7,255	291
1915	1,085	197	2,209	3,005,825	1,363,433	279,660	120,126	54,489	2,496

Year.	Chemicals. (*Continued.*)											
	Nitrate of Sodium.			Caustic Soda.			Soda Ash and Carbonate.			Sodium Salts, All Other.		
	Long Tons.	Metric Tons.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.	Lb.	Kg.	Value.
1906.	6,660	6,767	$324,915	(*l*)	.....	.....	2,486	1,128	$41	1,032,372	468,180	$21,624
1907.	7,159	7,274	370,048	(*l*)	.....	.....	3,100	1,406	53	742,201	336,662	16,099
1908.	9,955	10,113	514,799	(*l*)	.....	.....	4,645	2,104	77	834,207	378,726	18,255
1909.	8,233	8,365	377,571	(*l*)	.....	.....	(*l*)	.....	....	1,053,410	477,816	21,777
1910.	5,784	5,878	250,550	(*l*)	.....	.....	(*l*)	.....	....	333,427	151,282	11,767
1911.	6,787	6,896	269,274	(*l*)	.....	.....	(*l*)	.....	....	611,922	277,566	14,479
1912.	8,853	8,995	440,200	(*l*)	.....	.....	(*l*)	.....	....	431,407	195,685	9,416
1913.	5,560	5,653	295,111	(*l*)	.....	.....	(*l*)	.....	....	534,470	242,500	12,672
1914.	9,220	9,374	460,868	....	.....	.....	......	.....	....	....	....	13,654
1915.	22,943	23,318	1,123,761	....	.....	.....	......	.....	....	....	....	387,437

Year.	Coal, Bituminous.			Copper.						Graphite.	
				Ore and Matte.			Pigs, Bars, Ingots, Old, and All Unmanufactured.				
	Long. Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Lb.	Metric Tons.	Value.	Long Tons.	Value.
1906....	2,541	2,582	$13,062	71	....	....	1,567,782	711	$309,605	3	$362
1907....	1,947	1,978	12,199	....	72	$ 29,791	995,555	451	199,828	1	41
1908....	4,759	4,832	16,313	2	....	....	718,541	326	93,148	....	......
1909....	3,128	3,178	8,532	434	2	50	1,058,528	480	135,952	16	976
1910....	3,734	3,894	13,761	*Nil.*	441	5,600	55,857	25	6,443	34	3,192
1911....	3,718	3,778	10,296	*Nil.*	....	....	200	0.1	52	*Nil.*	......
1912....	982	998	6,574	*Nil.*	....	....	1,020	0.5	132	*Nil.*	......
1913....	1,179	1,199	6,652	*Nil.*	....	....	557	0.3	135	1	44
1914....	21,390	21,747	118,241	*Nil.*	....	....	3,436	1.6	534	*Nil.*	......
1915....	1,331	1,353	8,898	....	....	....	801,872	364	151,369	......	......

Year.	Iron and Steel.											
	Pig Iron.			Scrap.			Bar Iron.			Rails.		
	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.	Long Tons.	Metric Tons.	Value.
1906.....	6,750	6,858	$236,957	5,111	5,193	$101,886	61	62	$7,207	*Nil.*	....	.....
1907.....	2,921	2,968	86,420	157	160	3,378	38	39	3,959	*Nil.*	....	.....
1908.....	1,827	1,855	52,079	288	293	3,597	26	26	1,271	*Nil.*	....	.....
1909.....	720	732	25,936	....	....	......	20	20	1,500	*Nil.*	....	.....
1910.....	579	588	20,706	....	....	......	9	9	356	*Nil.*	....	.....
1911.....	1,837	1,866	73,987	100	102	1,373	12	12	635	*Nil.*	....	.....
1912.....	5,087	5,169	130.102	198	201	3,788	25	25	1,176	*Nil.*	....	.....
1913.....	765	778	29,257	70	71	771	68	69	6,099	49	50	$1,000
1914.....	*Nil.*	....	....	186	189	2,136	13	13	1,007	*Nil.*	....	.....
1915.....	109	111	8,527	90	91	1,063	408	415	13,043	181	184	5,632

Year.	Iron and Steel. (*Continued.*) Steel, Ingots, Blooms, Etc. Long Tons.	Metric Tons.	Value.	Sheets, Plates, Rods, Wire. Long Tons.	Metric Tons.	Value.	Tin and Terne Plates, Taggers Tin. Long Tons.	Metric Tons.	Value.	Lead and Mfrs.
1906	196	199	$14,104	318	323	$27,631	0.4	0.4	$28	$2,307,345
1907	292	297	25,974	14	14	1,220	42.2	42.9	1,813	2,416,082
1908	33	34	9,822	66	69	3,441	4.7	4.7	351	3,101,953
1909	60	61	10,389	42	43	2,630	14	14	6,273	3,139,908
1910	121	123	24,867	96	98	6,122	.....	.....	.....	2,511,850
1911	108	110	19,721	.....	.....	34,177	.....	.....	.....	4,067,574
1912	470	478	57,743	58	59	6,786	175	178	15,886	2,704,062
1913	418	425	60,191	*Nil.*	.....	......	1	1	250	2,107,796
1914	443	450	41,052	2	2	143	67	68	4,240	1,539,039
1915	153	155	27,262	88	89	6,112	139	141	9,018	1,082,948

Year.	Salt. Lb.	Metric Tons.	Value.	Sulphur—Crude. Long Tons.	Metric Tons.	Value.	Tin in Blocks, Pig and Granulated. Long Tons.	Metric Tons.	Value.
1905	611,912	278	$893	1,713	1,741	$36,858	557	567	$375,763
1906	1,462,413	663	1,129	403	409	8,475	807	820	650,411
1907	1,166,049	529	1,686	301	306	5,759	562	571	492,415
1908	2,525,945	1,146	9,352	380	386	8,500	244	248	156,761
1909	1,617,705	734	1,700	16	16	284	441	448	294,649
1910	2,124,983	964	2,173	5	5	145	620	630	467,526
1911	449,025	204	646	*Nil.*	......	....	1,012	1,027	958,481
1912	73,551	33	105	1,015	1,032	20,314	589	598	591,729
1913	76,125,400	34,540	3,226	25	25	555	1,104	1,122	1,135,105
1914	5,196,300	2,357	14,349	309	314	7,074	802	815	647,017
1915	10,384,400	4,712	31,841	175	178	3,995	553	562	439,443

(*a*) From Summary of Commerce and Finance of the United States. (*c*) Total exports of coin and bullion; that is, includes both foreign and domestic. (*d*) Only approximately correct. The Bureau of Statistics reports only the value of silver ores exported, but a much larger amount of silver leaves the country in copper matte, which is classified as copper ore, and no record is kept of its silver contents. The gold in copper matte exported is not included in the exports of gold given in the above table. These figures include ore of both domestic and foreign origin. (*e*) Includes nickel oxide and nickel matte. (*f*) Includes chlorate, chloride, nitrate, and all other salts of potassium. (*g*) Reported in barrels, but calculated to gallons, on a basis of 42 gallons to the barrel. (*i*) Barrel of 400 lb. (*m*) Does not include coal used for fuel on vessels for foreign trade. (*n*) Included in other manufactures. (*o*) Antimony contents of regulus, etc.

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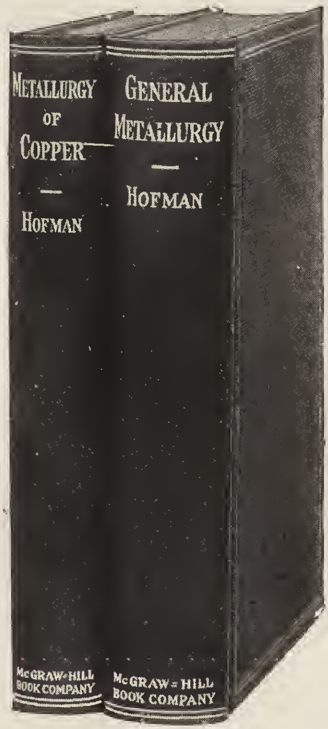

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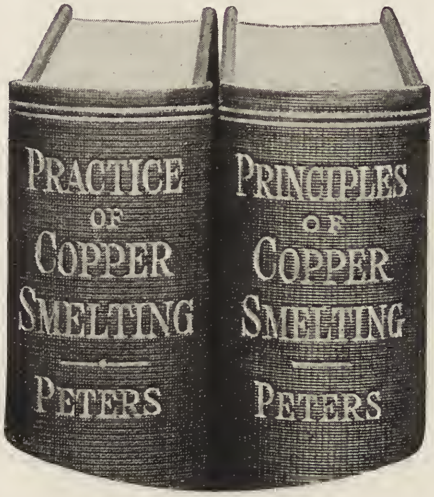

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